

75 cents

Aviation Week & Space Technology

JULY 2, 1962

A MCGRAW-HILL
PUBLICATION



NASA-Spearhead to Space



*High-Yield A-286 "Tensitized" Bolts by Voi-Shan

Today's aerospace fastening requirements demand a new dimension in fastener technology. Voi-Shan's "TENSITIZED" bolt series is the result of technological research and development expressly designed to meet this urgent need. Using A-286 and other super alloys, Voi-Shan's exclusive methods of manufacture offer these bolts at greatly increased strength levels with "Hi-Y" (significantly higher than the typical 80% yield tensile ratio). These bolts offer excellent mechanical properties through high and low temperature ranges. CRYOGENIC properties considerably exceed room temperature properties. Superior performance is further guaranteed by unusual resistance to corrosion in SALT WATER and other difficult aerospace environments. To make your fastening system complete Voi-Shan also offers mating locknuts for all of these super alloy bolts.

ALLOY	TEMPERATURE RANGE	ROOM TEMPERATURE STRENGTH LEVEL (psi)
A-286	-425°F — 1200°F	250,000 psi (Min.)
Nimonic	-425°F — 1800°F	240,000 psi (Min.)
Inconel 718	-425°F — 1900°F	260,000 psi (Min.)

Complete detailed information on Voi-Shan's "TENSITIZED" bolt series and other aerospace fastening devices is readily available. Write or call your company letterhead to:

VOI-SHAN MANUFACTURING COMPANY
A DIVISION OF VOI-SHAN INDUSTRIES, INC.
8403 HIGUSA STREET, CULVER CITY, CALIFORNIA



IMAGINATION PLUS

BENDIX-PACIFIC at work in space communications

25th

Compact and reliable, the Bendix-Pacific Series 300 Telemetry solid state, subminiature modules are components have set new performance standards in space communications. Behind the Series 300 is the "imagination plus" of Bendix-Pacific—creative engineering and over 16 years' experience in telemetry which have permitted to make Bendix-Pacific the recognized leader in this field. Now at work on virtually every major U.S. space vehicle.

Bendix-Pacific telemetry components are another example of the broad capabilities which have made Bendix-Pacific a leading supplier of equipment and systems for: Airborne Radar, Data Handling, Guidance, Navigation/Parasutic/Electromechanics, Military Navigation, Guidance and Telemetry.

For information on how Bendix-Pacific's "imagination plus" can go to work for you in any of these fields, write or call Bendix-Pacific Division, North Hollywood, California.

Bendix-Pacific Division

IN SKIES



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Moreover, Wyman-Gordon pioneering first brought to operational use many of the light metals, superalloys and refractory materials which have significantly advanced performance from jet outfalls to space craft spaces. Broad-front research in the industry's most completely staffed metallurgical and developmental laboratories continues to extend size, configuration and strength-to-weight design parameters of components for frame, propulsion, guidance and support applications.

Whatever the problem in forging any truly critical mission hardware, Wyman-Gordon experience can prove available to its solution—an engineering team stands ready to counsel on your design.

OR SPACE



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compact
t/d/r
for
compact
control
systems



Miniature AGASTAT
time/delay/relay offers
maximum reliability in minimum space

For control systems where reliability and size are important design considerations, specify the Miniature AGASTAT time/delay/relay.

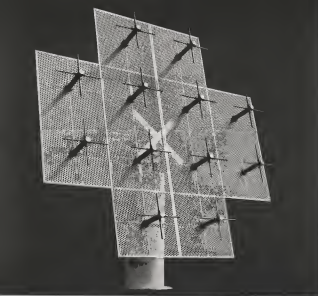
Only 1 1/2 in. square, less than 5 in. high, and weighs as little as 15 oz. Six adjustable models provide delays from .45 sec. to 2 minutes—on push-on or drop-out. Electrically-operated, pneumatically-actuated, or instant cycling and freedom from voltage variation drift. Choice of ac or dc operating voltages, with solder tag, cord plug or AN connector terminals.

Since 1951, AGASTAT time/delay/relays have been specified for reliability and accuracy in almost every industry with electrical control requirements. Wouldn't this be a good time to learn what this proven performance can mean on your timing circuit?

We'll gladly send complete details. Just write Dept. M2-17.

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IN CANADA: IRMA CANADA, LTD., 15 QUEEN ST., TORONTO 10, ONTARIO, CANADA



Specifications / Telemetry Antennas

The above display array is one of a family of high-performance tracking and reception antennas covering various telemetry frequency bands including 115-500 Mc and 500-400 Mc. These arrays have integral hybrids and provide both sum patterns and difference pattern outputs. Either manual or automatic anti-tracking systems can be incorporated with complete polarization diversity, right and left circular, horizontal and vertical linear. Light weight and flat configuration results in lower mass moments and inertia, allowing use of smaller mounts and less complicated servo systems.

ARRAY NO. 1 Medium Gain Array (shown) PERFORMANCE

Frequency Range:	115 Mc - 500 Mc
Gain:	17.5 db
Side-lobe:	55 db (V-shaped pattern)
	17 db (Diamond pattern)
Nut Depth:	35 db
Weight:	225 lbs
Size:	12' x 12' x 1' 5"
Beamwidth:	25.5 deg

ARRAY NO. 2 High Gain Array PERFORMANCE

Frequency Range:	115 Mc - 500 Mc
Gain:	22 db
Side-lobe:	26 db (AM pattern)
Nut Depth:	35 db
Weight:	425 lbs
Size:	20' x 18' x 2' 5"
Beamwidth:	14 deg



TOTAL CAPABILITY IN SOLID ROCKETS

RESEARCH...DEVELOPMENT
...PRODUCTION...FACILITIES



PRODUCTION

Aerojet-General has manufactured over 100,000,000 pounds of solid rocket propellants and delivered more than 700,000 solid rocket engines. One reason for this impressive record, Aerojet-General's unique continuous cast facility—capable of turning out solid propellant at the rate of 1,000,000 pounds a month—the only facility of its size and type in the free world.



SOLID ROCKET PLANT / Sacramento, California

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MADE IN U.S.A. This stamp on a Fafnir Ball Bearing means finest quality and workmanship... distributed freely... no additional engineering help... and availability in meeting your bearing needs. It's worth bearing in mind.

FAFNIR
BALL BEARINGS

Circle Number 8 on Reader Service Card

Sanborn® 7-Channel FM tape system for \$6800* complete

uses interchangeable FM and direct
record/reproduce electronics
entirely contained in 7" x 19" panel space



COMPARE PERFORMANCE, PRICE PER CHANNEL

Here is the ideal combination of high performance and economy in a 7-channel, 4-speed system that meets EECG Telemetry Standards. Versatility is another advantage. The Model 2000 system uses interchangeable Sanborn FM or direct record/reproduce electronics — all solid-state, in 7" x 19" panel space — and you can have any combination of direct and FM channels simply by changing circuit cards. Recording capability may be extended beyond the system's maximum input levels through the use of Sanborn "500" and other compatible amplifiers.

The Model 2000 Magnetic Data Recorder has four speeds and uses standard 1/4-inch tape on 2014-inch reels. All controls are on the front, and several convenience features are included: an integral FM Alignment Meter that eliminates the need for electronic counters, an automatic spooler, a tape footage counter, and provision for error rate channel for fault comparison.

Complete details are available from Sanborn Sales-Engineering Representatives in principal cities throughout the U. S., Canada and foreign countries.

*Price FOB Watling, Mass. in Continental U. S. & adjacent in dollars without taxes, duties and local freight and is subject to change without notice.

SPECIFICATIONS

Level ± 2.5 V into 60,000 ohms, single ended, adjustable
Output ± 2.5 V into 1,000 ohms or more, single ended, level, position adjustable.
Bandwidth (Max)

Speed	FM	Direct
3 1/2"/sec	0-420 cps	20-4,200 cps
7 1/2"/sec	0-1,200 cps	20-12,000 cps
15"/sec	0-2,500 cps	20-25,000 cps
30"/sec	0-5,000 cps	20-50,000 cps

 (100% modulation on FM \approx 40% carrier deviation)
 Linearity Max dc nonlinearity 0.5%
 Drift $\pm 0.05\%$ of full scale for 20 V power line change, 10°C ambient temperature change, or for 24 hours at constant power line voltage and ambient temperature.

Signal-to-Noise Ratio (Max)
 Direct: 40 db at all speeds
 FM: 45 db RMS at 30"/sec and 15"/sec;
 35 db RMS at 7 1/2"/sec, 23 db RMS at 3 1/2"/sec.



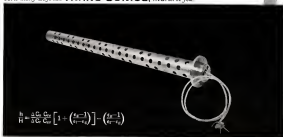
SANBORN COMPANY
ELECTRICAL DIVISION
178 Watling Drive, Watling, MA, 01981-0018



Steady, as well as input monitoring during magnetic recording, may be provided by this compatible 15-inch, 8-channel Viso-Scope or other Sanborn monitoring instruments, or by direct wiring system.

Circle Number 9 on Reader Service Card

How many ways can **TRANS-SONICS, INC.** serve you?



$$\frac{h}{H} = \frac{\Delta C}{\Delta C_{\text{ref}}} \left[1 + \left(\frac{t_c - 1}{t_c - t_0} \right) \right] - \left(\frac{t_c - 1}{t_c - t_0} \right)$$

LIQUID LEVEL

is measured in many ways. The sensor does it by means of resistance and forms part of a complete Trans-Sonics system. With its solid state black box, the sensor provides a direct output accurate to 0.1 inch in 4 ft.

Automatically corrected for density changes, the Trans-Sonics tank gauging system is suited for cryogenic as well as chemical fluids. It's a perfect fit for oil rigs and underground reservoirs, and with a response time of four milliseconds, it is now used to measure SLOF and EFL stage rates at an turbine compressor. The system provides important data relating to propellant utilization, booster segment distribution, and will safeguard the performance of critical aerospace assemblies.

Visible exposure is only one of several techniques used by Trans-Sonics for the measurement of level. Differential pressure, piezoelectric effects, and neutral buoyancy are also used for systems having either analog or digital outputs. From liquid hydrocarbons to air, water, Trans-Sonics divers can guarantee accurate and reliable results in the most demanding conditions — any way you want it. Write, call, or phone — 1-714



To put the rest in perspective...
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In Space Technology...LOOK TO PARSONS for Performance

Parsons has substantially aided... and will continue to aid... the United States in its military use and peaceful exploration of space. The design and field engineering, or construction of rocket fuel plants, static test stands, launch facilities, tracking complexes, ground and airborne electronics, in addition to feasibility studies for permanent lunar facilities to support men and equipment for indefinite periods, demonstrate the diversified capabilities of The Ralph M. Parsons Company.

The conquest of space will be achieved by industry and government working as a team. And teamwork, plus resources, plus services from Parsons all add up to total capability, single source responsibility.



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American Airlines has launched the most advanced jet airliner in the world—the 990 Astrojet.

Here is the new shape of commercial aviation. You will notice two extra aerodynamic bodies on each wing. These are speed capsules—designed to snarl out the airflow at high speeds.

Here is the new brain of commercial aviation. We believe the 990 is the strongest airplane ever built. It has

Adapted to a Selectee Fleet of American Airlines Term.

tremendous structural integrity. Many extra safety factors have been built into it.

And here is the new comfort of commercial aviation. Wide aisles. Wonderfully deep, wide armchairs. A spacious, club-like First Class section. And a pleasant surprise for jet travelers: 3 and 2 seating in the Coach section.

For a new experience in flying, try the next advanced jet in commercial aviation: the 990 Astrojet.

AMERICAN
WORLDWIDE LEADING AIRLINE



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Miniature rectangular "Herm"® provides high density connections, and is available in 34, 20, 26, 34, 42, 60 & 75 contact sizes with hoods to fit all sizes. Crimp type, snap locked contacts accommodate wire sizes #18 thru #26, and are removable without disassembling connector. Hoods are slotted with spring, wing type, crimp shell design... can be opened to remove or insert contacts without wiring removed from connector block. Crimped connections comply with MIL-STD-883C with extra work with all existing solder types. Complete line of summer installation tooling available. Write Service Division for details.

BURNDY
 Noner's, Connect.

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Through much of the information is elementary, an attempt is still to be of interest to many in the field, including some of those engineers who may find it useful to review fundamentals from time to time.

The Effect of Lead in Alloy Steels, PART I

The subject of leaded alloy steels will be discussed in two parts. Here we deal with basic definition, reasons for excellent machinability, and purpose of closely controlling the lead additive. Part II, which follows in this series, will touch upon working properties, and discuss when leaded alloy steel should be used.

WHAT IS A LEADED STEEL?

A leaded steel is any steel, carbon or alloy, to which lead has been added to improve its machining characteristics. This lead additive, generally held within the limits of .18 to .35 per cent, may be added to any standard AISI or SAE steel. The percentage of lead does not, to any practical degree, alter the mechanical properties of the base steel.

HOW LEAD IMPROVES MACHINABILITY

Theoretically, lead acts as a lubricant self-lubricating action which reduces friction at the tool-chip interface. This permits appreciably higher cutting speeds and feeds because leaded steels have a lower coefficient of friction than non-leaded steels. Also, because of the finely dispersed lead particles, there are minute interruptions within the matrix which cause a premature breaking of chips. This minimizes build-up within the tool-chip interface, prolonging tool life and improving machined finishes.

Optimum cutting speeds are commonly increased by 25 to 40 per cent. Sometimes, depending upon the condition and grade of steel and the type of machining, these speeds can be more than doubled.

LEAD ADDITION MUST BE CLOSELY CONTROLLED

Lead is distributed throughout the ingot by the addition of pure metal shot. It is forced into the molten steel stream during tamping (pouring from the ladle to the mold) by means of a fixed air-pressure gun. The lead shot, having a higher specific gravity than the molten steel, tends to segregate at the bottom of the ingot. This is controlled by pouring a predetermined amount of steel in the ingot prior to the lead addition.

Since the uniform distribution of lead is all-important to the machining properties of leaded alloy steels, Bethlehem exercises great care in (1) controlling the lead content through checking by the fluorescent X-ray method, and (2) inspection of billet specimens for lead distribution by means of evaluation tests.

Bethlehem metallurgists are "on the scene" where new applications of leaded alloy steels are being developed. If you'd like to consult with them on any problem, just write to us at Bethlehem, Pa. And remember, too, that Bethlehem makes a full range of AISI standard grades, as well as special-analysis steels, and all hot-rolled carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts About Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.



See Strength
See Economy
See Versatility



BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. Export Sales Bethlehem Steel Export Corporation

BETHLEHEM STEEL

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Circle Number 15 on Reader-Service Card

turning with tape puts precision and quality into

components for advanced space propulsion systems. Spherical precision for wind and explosion tanks, turned from light, high strength forgings, are the result of the super precise details the Flight and Space Division produces on Ex-Cell-O Numerical Tool Machines—the most accurate production machine tools ever built. These numerically controlled machines, augmented by equally sophisticated fabricating facilities, are a dependable source for the most demanding powerplant and vehicle components. For detailed information, contact our Representative in your area, or call or write direct. Phone 313 868 3500 TWX DE-175



For more information, write to us at Bethlehem Steel Company, 1000 Locust Street, Philadelphia, PA 19107

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Circle 15 on Reader Service Card

XLO



B.F. Goodrich has both feet in space

A vision of yester's leather-jacket days, B.F. Goodrich is now one of the most versatile players in aerospace technology. The Project Mercury Astronaut suit is one notable achievement. This suit protects man from heat, from cold, from other space hazards, has built-in communication and air conditioning systems. Next advance will be the space suits BFG is perfecting for crewmen of larger orbital vehicles.

STRUCTURES FOR THE HOT BLUE YONDER. Another skill BFG has mastered is the technique of insulating steel cones and heat shields to withstand re-entry



temperatures in the thousands of degrees. We've played a leading role in making rocket motors of plastic and glass fibers. These cones replace metal, add hundreds of miles to missile range.

THE CONQUEST OF ICE. Ice can be as deadly as heat. BFG has led the way in developing ice protection systems for aircraft, beginning with the first DeLorers which opened the era of all-weather flight. BFG systems now provide protection for jets and missiles. Present capability includes pneumatic De-Icers, metal-clad electric thermal De-Icers, heated rubber and plastic parts.



ROCKET FUELS "BOILING" WITH RUBBER. Our knowledge of polymer chemistry led to development of the major binder fuels used in the most advanced solid fueled rockets. The newest BFG solid propellant parts were punch thru previous rubber-based fuels over an extreme temperature range.

JET SAFETY. The most advanced tire ever built has been developed and produced by BFG for a Mach 3 aircraft. It's built to withstand even-hot temperatures of 380°F for prolonged periods. And the newest brake allowed for jet service in the BFG liquid cooled brake, which contains through repeated "reheat-to-ice-off" stops.

A brochure, "B.F. Goodrich Resources for Missile and Rocket Progress" tells a detailed story of BFG capabilities. Write for a copy, and tell us of your particular product interest. B.F. Goodrich Aerospace and Defense Products, a division of The B.F. Goodrich Company, Department AW-78, Akron, Ohio.



B.F. Goodrich

BENDIX COUNTDOWN FOR SPACE

7

PERMITS CONTROL: An on-board computer is being developed for space control systems early entry and launch control system. An on-board computer is being developed for space control systems.

6

SELF-ADAPTIVE CONTROL SYSTEM: Capable of measuring dynamic behavior and adjusting feedback gain, the system will allow control of a system without requiring manual intervention. Also, the system will be able to adjust itself to a new system. Being developed under USAF contract.

5

SATELLITE CONTROL AND STABILIZATION: Eclipse Pioneer 100 will be built around a computer system. It will be able to control a satellite in orbit. The system will be able to control a satellite in orbit.

4

STAR TRACKER SYSTEM: A system incorporating both a star tracker and a star tracker is being developed. It will be able to track a star in the sky. The system will be able to track a star in the sky.

3

SPACECRAFT RENEGOTIATION COMPUTER: A computer system is being developed for spacecraft negotiation. It will be able to negotiate a spacecraft's path. The system will be able to negotiate a spacecraft's path.

2

ADVANCED DISPLAYS AND CONTROLS: A system is being developed for advanced displays and controls. It will be able to display a spacecraft's path. The system will be able to display a spacecraft's path.

1

LANDING, APPROACH, AND DEPARTURE: A system is being developed for landing, approach, and departure. It will be able to land a spacecraft. The system will be able to land a spacecraft.



Knowmanship in Action

Technical knowledge, management ability, and craftsmanship all add up to Eclipse Pioneer's space-age Knowmanship. We pride ourselves on anticipating our customers' needs—and meeting them with technical

advancements based on specific requirements. The manufacture of precise components and total subsystem capability are typical of our creative ability as a major contributor to the field of space technology. By applying principles of Knowmanship, we're able to

achieve our space missile research and development for tomorrow's intriguing challenges, products for the critical needs of today. White, Telford, New Jersey.

TECHNICAL KNOWLEDGE — EXPERIENCED MANAGEMENT
— SPECIALIZED CRAFTSMANSHIP — KNOWMANSHIP

Eclipse-Pioneer Division



Weld failures cut 89% using vacuum-melted filler wire

[Weld tests on alloy steel wire used in missile applications revealed also times as many failures with air-melted wire as with Cannon-Muskegon vacuum-melted wire] [Superior to gas-tungsten-arc electrode welding, Cannon-Muskegon vacuum-induction melting greatly reduces gas levels (nitrogen less than 25 ppm, oxygen less than 25 ppm, hydrogen less than 5 ppm) Combined sulphur and phosphorus less than .015%]

[These remarkably low gas and impurity levels can be most efficiently obtained with Cannon-Muskegon vacuum-induction melting. You are invited to visit Cannon-Muskegon for further details]

Among test samples prepared from air-melted wire, 11 out of 20 failed at the weld]

Among similar samples prepared from the vacuum-melted wire of the same grade, only two out of 20 bars failed at the weld]

[Different alloys of Cannon-Muskegon vacuum-melted welding wire are available in sizes .089" to 1/2", in 36" and lengths, or in 10 or 20-lb. spools packed in airtight Argon-filled steel containers]



CANNON-MUSKEGON CORPORATION
Melvindale, Pennsylvania • 2877 Lincoln Street • Muskegon, Michigan

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APPROVED

SIL-TEMP

Having's high purity Silver Temp
with a melting point of 3000° F

This unique product is now being used by all major missile engine factories in the United States. Some of the larger missiles where SIL-TEMP is being used as an additive component are the Minuteman, Polaris, Titan I, Titan II, Nike-Zeus, Dyno-Sear, Sahara, Scout, Apollo, Navajo, Skybolt and Surveyor.

Other missiles which are now all being ordered in practically large numbers include the Viper, Mauler, Skyknight, Bulldog, Sabre and Asp.

SIL-TEMP was chosen for this all important program because of its superior quality and product uniformity. SIL-TEMP gives better abrasive properties, strength characteristics and reliability than any product ever being offered anywhere. Having's quality control and experienced engineers are definitely responsible for this "fast-track" accomplishment.

For further information on the use of SIL-TEMP in the missile, engine or chemical field where high temperatures are involved, write, wire or phone for folder giving complete data. Our experienced engineers will be happy to work with you on your particular application.



SIL-TEMP DIVISION, HAVEG INDUSTRIES, INC.
P.O. Box 100, Wilmington 3, Delaware

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fight paperwork
when 3M makes
microfilm so easy to use!



Microfilm is fast replacing costly paperwork in hundreds of companies. And 3M is making it so easy—with 3M Microfilm Products. For example, the FILMSORT® Aperture Card, a standard tabulating card containing a frame of microfilm, makes it easy and economical to file, retrieve, reproduce, distribute information—Instantly! Does for pennies what it now costs you dollars

to do in paperwork. Cuts file space 96%. And THERMO-FAX™ "Filmac" Reader-Printers make enlarged copies from microfilm, seconds fast! To learn how your company can replace paperwork with easy-to-use microfilm write to the 3M Company, 900 Bush Ave., Saint Paul 1, Minn.

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WESCON BOOTH 909.



For Technical Data and prices, contact:

SILICON TRANSISTOR CORPORATION
CUTLER PLACE, LONG ISLAND, NEW YORK 11760
Phone: 3-4800

Silicon-Germanium PNP Types:

11/16" max., 85 watts... 5TC5550 through 5TC6550
Square package... 85 watts... 2P359, 2P359A, 2P424, 2P424A
TO 18... 75 watts... 5TC5280 through 5TC5580
Omnipack form: 1/2 to 3/4" x 2 angles... 1/4 (3/8) 0.5 ohms
x 2 wires... V_{CE} 50 volts... I_B max 5 amps

Si-Ge Complements:

11/16" max 85 watts... 5TC1590 through 5TC1595
Square package 85 watts... 2N559, 2N559A, 2N424, 2N424A
TO 3 75 watts... 5TC1590 through 5TC1595

HUSKIE... first with a unitized unlimited life transmission drive system...by Western Gear

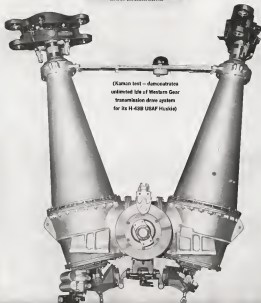


Much more than just component testing! Kaman Aircraft Corporation has established an unlimited life on a completely unitized helicopter transmission drive system for its H-43B USAF "Huskie." This transmission drive, built by Western Gear, was designed as a "unitized" system because of the Huskie's unique intermeshing rotor configuration. The entire system, including

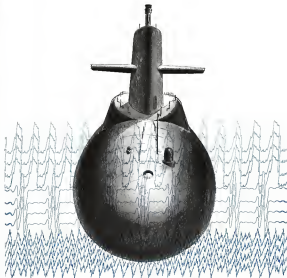
rotating controls, hydraulic drive and pump, and governor drive and pump can be lifted out and changed as a single unit. Learn more about Western Gear's work with advanced concepts in high speed gearing and shafting. Address: Precision Products Division, WESTERN GEAR CORPORATION, P.O. Box 192, Lynwood, California. Cable address: WESTGEAR, Lynwood, California.



POWER BY WESTERN GEAR



(Kaman test — demonstrates unlimited life of Western Gear transmission drive system for its H-43B USAF Huskie)



new approaches to silence and shock protection

The Navy is always on the lookout for better ways of suppressing sound and attenuating shock. Lord has devoted its special talents to meeting these needs. Here are a few of the results. ■ Modular components and lubricated strikers for mechanical damping. Main drive couplings that transmit power smoothly, silently. Efficient covers to seal in sound. Dock mountings that isolate entire compartments. The only complete line of Navy machinery mountings. Protective suspensions for aerial navigational systems. Special mounting systems for electronic gear. ■ To develop new approaches, Lord dives deep into problems, explores them thoroughly, often charts new courses in vibratory/shock/noise control. Don't expect just a routine answer from Lord. Expect more. Contact: Lord Manufacturing Company, Erie, Pa. Field Engineering Offices in principal cities. In Canada: Railway & Power Engineering Corp., Ltd.



vibratory/shock/noise control

PASSENGERS AND AIRLINES

love them!

20 CARAVELLE MEDIUM-RANGE
JETLINERS ARE ALREADY
IN SCHEDULED OPERATION
ON U.S. DOMESTIC ROUTES



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ANOTHER SPECTACULAR SATURN LAUNCHING!

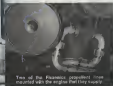
**... with flex-metal tubing
and ducting from Flexonics**

Now the world has witnessed another highly successful launching of the mighty Saturn developed by National Aeronautics and Space Administration—the United States' largest space vehicle, producing more than 1,300,000 pounds of thrust. Vital to this outstanding performance are a total of 138 Flexonics gasepoxies and other items that supply fuel and oxygen to the cluster of eight Rocketdyne engines, as well as Flexonics interconnect and power-actuation lines, and high performance metal hose.

Engineers from Flexonics and George C. Marshall Space Flight Center, Huntsville, Ala., worked together in the design of these components, just as they are now at work on future Saturn configurations. Teams of design and fabrication specialists adapted Flexonics precision forming methods to the unique requirements of the Saturn Executive qualification tests, under simulated flight conditions, proved the soundness and reliability of design before the countdown of the first flight.

To simplify and expedite resolution of your next ducting problem, call on Flexonics.

Write for your copy of the big new Flexonics Engineering Guide and catalog of aerospace components.



Two of the Flexonics gasepoxies from mounted with the engine fuel they supply.



Close up of one of the Flexonics GOK "Y" connector high-pressure manifolds.

Flexonics

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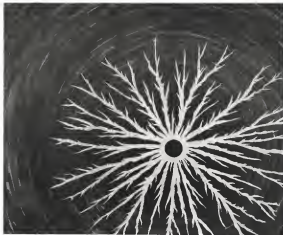
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This related work applies to the erosion of electrons which occurs at the time of metal abrasion or fracture. Related measurement techniques in regard to this factor may lead to the detection of microscopic cracking long before failure ... allowing for part replacement before the onset of fracture in service. □ Triboelectrodeposition is only one of many phenomena involving metal behavior now under study at Douglas. Because structural reliability is a critical consideration in the design of transonic, supersonic and hypersonic aerospace vehicles, Douglas laboratories are engaged in a

TRIBOELECTROEMANESCENCE

...AND WHAT DOUGLAS IS DOING ABOUT IT

comprehensive research program relating to metal endurance. This includes corrosion causes and effects, environmental studies, and the effects of steady state loads and intermittent strains under cryogenic through pyrolytic temperatures in causing cracking.



This comprehensive study of metals is one of more than 600 research programs at Douglas. The focus is on technological advancement to meet the needs of a future which will include Douglas aircraft, subsonic, supersonic and spaceplane vehicles.

DOUGLAS

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The nation's new nerve center for outer space exploration is under construction in Houston ... with Brown & Root, Inc. the prime contractor for engineering and design.

The NASA site is only a few miles from the headquarters of this world-wide engineering and construction company. Over 600 engineers and engineering technicians are on our permanent staff at the Houston base.

No company is as intimately familiar with the NASA program at Houston ... and with the Houston area ... as Brown & Root. Many companies related to the space effort are moving to this area. Perhaps your company is one of them. If so, we can save you time and money in the fields of plant location, design, construction, purchasing, and maintenance. We invite your inquiries.

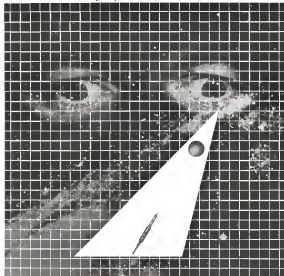


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Engineers • Constructors

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"... the faculty of perceiving in an unhabitual way."



Notwithstanding the fact that William James turned his phrase to define genius, perceiving is an unhabitual way in inherent in the philosophy of the United Aircraft Corporate Systems Center. Here, innovation's military and space systems are the objective — their development, management and production. While C.S.C. initiatives and programs inherit a legacy of leadership from well-known divisions and subsidiaries of United Aircraft, the breadth and depth of this systems approach takes them far beyond the familiar.

Typical of the highly advanced systems currently being studied are those involving mobile ballistic missiles, terminal air defense, orbital rendezvous and satellite navigation and control. Also, under contract to the U. S. Air Force, C.S.C. is designing and developing a sophisticated system of active inertial guidance, while the air-independent Weather System Center is studying the Air Force and P.A.A. in developing vastly improved methods for weather data collection, transmission and forecasting.

In the viewpoint of a corporate complex known for its pioneering achievements, the Center is well situated to carry forward its

programs. As "working tools", impressive nearby R&D facilities of United Aircraft are among the most capable in the industry.

Expanding programs have created many desirable openings for men who hold degrees in engineering or the sciences. Opportunities are available in: Guidance & Control Systems • Weather System Division • Computer R&D • Electronics • Manufacturing Planning and Control • Space Systems Requirements • Operations Analysis • Advanced Weapons Systems • Advanced Programming • Chemical Design • Electronic System Engineering. You are invited to submit your resume in confidence to Mr. T. W. Wynchel, Personnel Manager, UAC Corporate Systems Center, Windsor Locks, Connecticut — an equal opportunity employer.

**United
CORPORATE SYSTEMS CENTER
Aircraft**

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Carrying a 5505 lb. payload, a U.S. Army Apache helicopter, powered by an Avco/Lycorning T53 gas turbine engine, recently set a new world's payload-to-altitude record for helicopters by flying the previous payload record by 1975, the previous record held stood at an altitude of 15,360 feet.

Rollway Bearings help push helicopter Somewhat higher than Gilroy's kite!

The standards of performance and reliability were demanded of the vital components located for this record-breaking powered flight.

With two bearings located both in the Avco/Lycorning engine and in the Rotax transmission, Rollway is proud to have participated in this outstanding performance.

When you need a bearing with reliability plus in a critical location, you are invited to take a critical look at Rollway Air-Rol Bearings. Rollway Bearing Co., Inc., P. O. Box 1387, Spiceland, N. Y.



Close-up view of the Avco/Lycorning T53 gas turbine engine which powered the Apache helicopter.

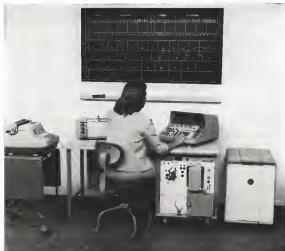
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Servomachronics, Inc. uses Recomp II for the simulation of space systems at its research center near Santa Barbara, Calif.

How to lease a physical laboratory for \$2,495 a month.

It weighs a little more than 500 pounds. It's just a bit larger than a desk. And it goes to work when you plug it in.

It can work as a flight test facility, a thesaurus, an electronics test bench, an environmental test chamber, a space system simulator. And that's just the short list.

This particular laboratory is called Recomp II. It is an advanced, solid state digital computer.

It's amazing the number of things Recomp can do. One big asset is the way it frees technical personnel for creative work.

For example, a company that used to get 2 proposals a year from a top creative scientist, was able to increase this figure to 30, with a computer (not Recomp). But with Recomp the company is now able to get ten proposals per man each year.

Recomp's accessory line and software advantages are the most up-to-date in the computer industry (they now include an xy graph plotter and card reader capability). And an extensive

programming library is available without charge.

There is a Recomp II to fit your needs (and budget). For medium scale needs, Recomp II starts at \$2,495 and with a complete line of peripheral equipment goes up to \$4,500. Recomp II is perfect for small scale needs. You can lease one for \$2,495, complete.

There is only one way to know exactly what computer suits you best. That's through your own feasibility study. And no computer feasibility study is complete without Recomp. Put Recomp side by side with any comparable computer on the market. Let the facts speak for themselves.

We'll be glad to help you get all the facts. Write today for a helpful guide: "How to Conduct a Computer Feasibility Study."

Write: Recomp, Department 27, 3400 East 70th Street, Long Beach, California.

Recomp



Recomp is a product of Autonetics Industrial Products. Autonetics is a Division of North American Aviation.

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Turn right at Orion

Stretching a point? Not really. Although the constellation Orion is more than 200 light years away, two of its stars, Betelgeuse and Rigel, stand out as logical navigation points for space missions.

Norden has built and tested two key components for space missions requiring stellar inertial guidance: (1) An all-attitude, four-graball inertial platform suited to meet space vehicle size and weight requirements. (2) An accurate star angle sensor which, through star-fix checks at periodic intervals, can correct platform drift. These self-contained instruments emit no signals and require no earthly contact, yet they could maintain the path of a craft through space indefinitely.

Producing inertial platforms and star tracking devices for stellar inertial guidance systems is evidence of the kind of engineering foresight Norden consistently applies to one primary mission... Extending Man's Capabilities.

FOR ADDITIONAL INFORMATION ABOUT NORDEN HARDWARE FOR STELLAR INERTIAL GUIDANCE SYSTEMS, WRITE:

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can we
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the answer

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POSITIVE-LOCKING QUICK-RELEASE

BALL-LOK PINS

AVDEL DOUBLE ACTING PIN

Push-pull in operation, ideal for heavy loads requiring absolute safety. Three handle styles. Pins have built-in bend for easy attachment. Standard pins available up to 1" diameter.



1/2" RING HANDLE
Push-pull pin available up to 1" pin length, up to 1" diameter. Positive locking.
Refer to catalog AVDEL 1127



1" T HANDLE
Push-pull in operation, easy to insert and remove. Positive locking. Largest of ball-locks.
Refer to catalog AVDEL 1128



1 1/2" T HANDLE
Push-pull in operation, Positive locking. Standard pins up to 1 1/2" pin length and 1 1/2" diameter.
Refer to catalog AVDEL 1129

AVDEL SINGLE ACTING PIN

Simply push the button to insert - repeat the action to remove pin. Three handle styles and related Pin handle styles, with hook for tapered attachment.



1/2" BUTTON HANDLE
Pin plug in place instantly. Positive locking and release. Aluminum or steel handle.
Refer to catalog AVDEL 1130



1" BUTTON HANDLE
Push button in insert and remove instantly. Hook for easy pin attachment.
Refer to catalog AVDEL 1131



1 1/2" BUTTON HANDLE
Two finger grip for instant removal. Standard pins up to 1 1/2" pin length and 1 1/2" diameter.
Refer to catalog AVDEL 1132



1/2" RING HANDLE
Pin handles in steel, repeat in bronze. Positive locking and release. Refer to catalog AVDEL 1133



1" T HANDLE
Pin handle with integral pin. Push-pull in place. Positive locking and release. Refer to catalog AVDEL 1134



1 1/2" T HANDLE
Pin handle with integral pin. Push-pull in place. Positive locking and release. Refer to catalog AVDEL 1135



1 1/2" BUTTON HANDLE
Two finger grip for instant removal. Standard pins up to 1 1/2" pin length and 1 1/2" diameter.
Refer to catalog AVDEL 1136



1/2" RING HANDLE
Pin handles in steel, repeat in bronze. Positive locking and release. Refer to catalog AVDEL 1137



1" T HANDLE
Pin handle with integral pin. Push-pull in place. Positive locking and release. Refer to catalog AVDEL 1138



1 1/2" T HANDLE
Pin handle with integral pin. Push-pull in place. Positive locking and release. Refer to catalog AVDEL 1139



1 1/2" BUTTON HANDLE
Two finger grip for instant removal. Standard pins up to 1 1/2" pin length and 1 1/2" diameter.
Refer to catalog AVDEL 1140

AVDEL DETENT PIN

Push-pull in operation, ideal for heavy loads requiring absolute safety. Three handle styles. Pins have built-in bend for easy attachment. Standard pins available up to 1" diameter.

AVDEL GROUND EQUIPMENT PIN

Push-pull in operation, ideal for heavy loads requiring absolute safety. Three handle styles. Pins have built-in bend for easy attachment. Standard pins available up to 1" diameter.

AVDEL GROUND EQUIPMENT PIN

Push-pull in operation, ideal for heavy loads requiring absolute safety. Three handle styles. Pins have built-in bend for easy attachment. Standard pins available up to 1" diameter.

AVDEL "SPECIAL" PINS are available for unique applications, including tongue pins. Many "specials" are unusual release methods such as release, hydraulic fluid, air, and others. Avoid expert expense in your area, our help you solve your problem and release problems. We would like to hear from you.

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Nuclear experience . . . aerospace . . . marine . . . automotive . . . industrial! Harrison's engineering team brings to your job an unusual breadth of knowledge backed by unmatched experience in every field where temperature control is a problem. This pool of experience is one reason Harrison can "engineer-in" performance characteristics matched precisely to each application . . . why Harrison heat exchangers provide maximum reliability and efficiency through the full operational range! For assurance of lasting quality, complete product dependability . . . focus Harrison's "experience in breadth and depth" on your temperature control problems—aircraft, missile or space vehicle!



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You can lock onto any of 20,000 frequencies — from 2 to 30 megacycles — inherently and firmly with the General Dynamics/Electronics — Rochester digitally tuned SC-900 series SSB equipment. With these rugged, highly transistorized sets, General Dynamics/Electronics — Rochester has advanced the state-of-the-art in radio communications. This complement of Single Sideband equipment includes transmitters and transceivers, which speak with all the range and authority of 1000 watts PEP, yet occupy less than a 20 inch cube and weigh well under 200

pounds. By simplifying both receiving and transmitting circuits, General Dynamics/Electronics — Rochester has achieved a significant advance in Single Sideband economy, reliability and ease of operation. Over 65 years of communications experience are built into the SC-900 series — a family of inherently SSB equipment developed by General Dynamics/Electronics — Rochester for all the branches of the Armed Forces.

Every product we make starts with a question: *What would you want?* Write 1413 North Goodman Street, Rochester 1, New York.

GENERAL DYNAMICS | ELECTRONICS — ROCHESTER

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J-M Microbestos and J-M Micro-Quartz Fiber used to reinforce high-temperature plastics

From Johns-Manville, manufacturers of Mica-K and Thermoxene (the only thermal insulators used aboard the Mercury Spacecraft), come two equally important products.

J-M Microbestos Paper and J-M Micro-Quartz Fiber. They are designed to provide reinforcement for high-temperature plastics such as exhaust nozzles, nose cones and semi-dynamically heated surfaces.

Microbestos Paper is a high-purity, high-bulk, uniform paper made of asbestos or asbestos in combination with other organic and inorganic fibers and fillers. It is capable of accepting up to 60% resin saturation. Microbestos-reinforced products saturated with various resin systems are available from leading manufacturers of laminating sheets, tapes, and molding compounds.

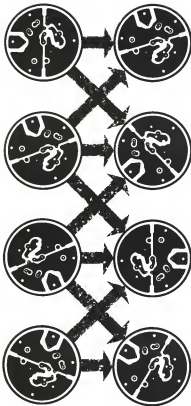
Micro-Quartz is made of the highest purity silica fiber with thermo-physical properties similar to those of pure silica. It is available in bulk form in various fiber diameters for use as a reinforcement for high-temperature and abrasive plastics.

For full details on these and other J-M aerospace innovations, write to J. B. John, Vice President, Johns-Manville, Box 14, New York 14, N. Y. In Canada: Post Credit, Ontario: Cable: Johnsonville.

JOHNS-MANVILLE 

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41



NEWS OF DEFENSE TECHNOLOGIES

DATA

To perform effectively, modern defense systems must continuously evaluate every dynamic situation within their environments. Data must be quickly collected, rapidly compared with voluminous memories, and be presented in an organized, accurate and lucid display—in real time. All this is done by human judgment, that unassailable prime factor of military strategy.

General Electric has played a major role in advancing the techniques of data utilization and display far beyond their early forms where manual computations of range and track data were accomplished at the plot board. In 1950, for example, General Electric introduced the AN/GPA-35 Radar Course Directing Group, the first mass produced equipment to perform semi-automatic tracking and automatic computation of the intercept problem. Later developments included the AN/FSA-83 Detection Tracking Group—the first equipment to demonstrate automatic detection and tracking of radar targets in all three dimensions—and the new Air Weapons Control System 612L, which provides the U. S. Air Force with the most modern airspace management system available.

Today's accelerating progress in data techniques is evolving from long-ago advances in logic and memory circuits and display techniques, and from an expanding scope of responsibility for the data processing and display functions. General Electric continues to make significant contributions to these techniques.



340 MICROBYTE LOGIC SYSTEM, the first to take full advantage of the ultra high speed capabilities of the hybrid diode, operates 20 times faster than previous circuitry.



ORGANIC ASSOCIATES REMOTELY CONTROLLED COMPUTER functions like a human brain by independently comparing and evaluating a new fact with all data in its memory.



THREE DIMENSIONAL DISPLAY provides a realistic, perspective of all spatial activity within its radar's range, in true perspective with scale references in all three dimensions.



CONSOLE ANALOG DISPLAY transfers digital data to "port" a moving TV picture of the ground onto the observed real ground.



TSP-16 DATA SYSTEM receives up to 42,500 characters a second via manual cable or microwave radio to link central processing equipment with remotely located computers.

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DEFENSE ELECTRONICS DIVISION

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ONLY AAF OFFERS COMPREHENSIVE, ONE-SOURCE CAPABILITY IN ENGINEERED ENVIRONMENTAL SYSTEMS



Packaged Drive Cooler. Self-contained unit incorporates refrigeration compression, heater drying, all associated components, controls. Cooling output, 47,000 BTU/hr. Bulk filter, a 150° F condensing trap; and 100° F ambient temp., 3000 ft. altitude.



Air Conditioner Unit. Complete, modular constructed unit has supply fan, chilled water supplied air cooling coil, air filter, automatic trap control and alarm sensors. Fresh air filtration capable of removing 99.97% of all particulate matter over 0.3 microns in size.



Air Conditioning Unit. Complete, modular constructed unit contains supply fan, chilled water supplied air cooling coil, air filter, air flow control dampers, automatic trap control and alarm sensors. Designed to withstand shock load in any direction.



Emergency Cooling Unit. Contains DC-powered venturi fan, DC-powered circulating pump, chilled water supplied air cooling coil, an AC-powered normal-service water circulating pump. Automatic controls for each component. Will withstand shock load in any direction.



Air Conditioner Unit. Provides fully modular conditioned, filtered air supply with 3-stage cooling, 3-stage heating, integral, fused, 100% type, electric resistance heaters. Cooling output, 42,000 BTU/hr.; and 41 ± 125° F. Heating output, 51,000 BTU/hr.

YOUR PROBLEM

in engineered environmental control may be similar to problems we've already solved for others. Shown here are a few examples of specialized equipment AAF has designed and produced for such unique systems as Nike Zeus, Atlas, Minuteman and Pershing. Both in engineering knowledge and in research, testing, and production facilities we have proved capability to meet specifications such as MIL-B-27542, GM 67-59-3517A, G-133-2 and other stringent specifications.

Engineered Environmental Systems

HEATING
VENTILATING
AIR FILTERING
REFRIGERATION
HUMIDITY CONTROL

Write for details today



Air Conditioner CM-100A. Has both automatic and manual controls, integral and remote controls. Fully insulated conditioned air supply with 3-stage cooling, 3-stage heating. Cooling output, 30,000 BTU/hr rated at 41 ± 125° F. Heating output, 51,000 BTU/hr.



Explosion-proof Portable Heater. Designed to meet MIL-B-8970 Environmental and MIL-44-7797 performance. Delivers heated air while operating within hazardous atmosphere. Triple over-riding temperature limit controls. Unit grounded against static electrical build-up.



The Whitfield Ultra-Clean Work Bench will exceed full-scale requirements as shown in the photo. 12 10 10 10 10 10 10 10

NEW WHITFIELD ULTRA-CLEAN WORK BENCH 500 TIMES CLEANER, PROVIDES FREE ACCESS, REQUIRES NO SPECIAL CLOTHING

Now you can have an open, room-sized, literally ultra-clean work area with none of the usual cleanroom restrictions! The Whitfield Ultra-Clean work bench continually bathes the work area with an ultra-clean air flow that carries particles away from the area before they can settle. Because the clean air flows from the bench, the dust count of the room and its personnel do not affect bench cleanliness. No gloves, special clothing, hoods or shields are necessary. Personnel have complete free access to the work area, with a dust

count of less than 1000 0.5 to 5 micron particles per cubic foot maintained. This is 500 times cleaner than any other clean room or bench. The Whitfield Ultra-Clean work bench provides a work area of 8' x 8' x 6', it has a self-contained air supply and requires only 110 V.A.C. power. With the compact Whitfield design, continuous ultra-clean airflow can be had by simply adding benches. Get complete information on the new Whitfield Ultra-Clean work bench now by mailing the below coupon.

ULTRA-CLEAN, ULTRA-CONVENIENT! Clean air flow from the bench bathes work continuously. Sample from air flow to wear any special clothing has low particle counts in the work area and no special clean room suit.

Please send me complete information and documentation on the Whitfield Ultra-Clean work bench

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PROVEN CAPABILITIES READY NOW!

Curved, Carved, Contoured Parts To Your Specifications

12 years' experience in perfecting techniques for pre-curing, reinforcing, carving, edge-bonding and finishing honeycomb parts—we build aluminum and reinforced plastic containers. These are Hexcel's qualifications to help you achieve even

the most complex combinations of reinforced and spherically curved parts. You make no investment of time and money to turn and stack-up; parts are shipped to you ready for bonding!

Typical Hexcel Pre-Curing Capabilities

CYLINDRICAL BARGE

Normal Expanded Honeycomb—4x Thickness
Over-Expanded—1x Thickness

SPHERICAL BARGE

1x Thickness at one-point nose caps
4x Thickness over small areas of large pieces
Segmented Assemblies—1x Thickness

Finished Honeycomb Case Assemblies—including several of the above combinations, bonded edge-bonded, ready to use.

Engineering Consultation On Honeycomb Parts

Hexcel's primary role in development of honeycomb has resulted in design of special tooling for pre-curing and machining. Hexcel engineers will work with you in manufacturing your own forming equipment from Hexcel drawings, and they in turn will tell you own engineers are

trained in proven techniques for making honeycomb. Hexcel engineers can also consult with you on which combinations of honeycomb material and forming techniques will best help attain your specific strength, temperature and cost requirements.

Hexcel Honeycomb Capabilities Proven In Major Projects

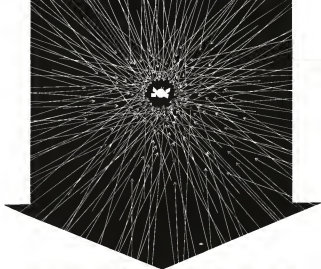
Featured above are some of the major aerospace projects in which Hexcel has applied pre-cured, contoured or carved parts. General Dynamics, Autonetics, Atlas-Craft, NASA's

Saturn and McDonnell's F4H are stronger, lighter, faster thanks to Hexcel Honeycomb technology.



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Strong, light, versatile honeycombs

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HOW TO LISTEN TO 160,000 SPACE MESSAGES—INSTANTANEOUSLY!

A satellite in orbit has a lot to tell. It sees the birth of a hurricane, feels the bombardment of radiation, jays into new space highways. Then it builds this information to send to the lists of millions of electronic signals. A Beckman system pattern and translates them to a common language, is capable of delivering 160,000 messages every second—without error in a row.

With a similar Beckman system you can check a prototype circuit through its real causal tests—before on design long before actual flight. Or run continuous checks on a

permanent reference measure the quality of industrial output and the safety of workers. Other Beckman instruments analyze the rhythmic pattern of a single switch doctor before the order is delivered, measure and monitor the air in nuclear submarines. Beckman instruments, systems, and components are at work throughout the world in laboratories, production lines, and defense installations. Remarkable what you—and a Beckman system can do. If you have a problem in analysis, measurement, or control, write to our Director of Marketing.

Beckman

INSTRUMENTS INC.
Fullerton, California

Circle Number 47 on Reader Service Card

COUNTDOWN ON RELIABILITY

Reliability typifies the Stearns-Roger staff of specialists in the fields of missile, cryogenic and nuclear facilities. Reliability requires the dedicated services of experienced and competent engineering personnel in the areas of criteria development, design, procurement, installation, check-out and operation.

Rely upon Stearns-Roger capability gained over the years in the Atlas, Titan, Minuteman, Saturn and associated programs.

With proven management and dependable, integrated engineering and construction staffs, Stearns-Roger can function under any contract to provide single responsibility for your requirements.



- 6 Management
- 5 Engineering
- 4 Procurement
- 3 Installation and Checkout
- 2 Systems Manuals
- 1 Operation and Maintenance



ELECTRO-COMBUSTION DEVICES AND SYSTEMS

for land sea and space applications



hi-shear

developed Electro-Combustion Devices serve a dual function. First, they act as high strength fasteners, consoles or as a means of containment. Secondly, on command, the devices are electrically initiated, releasing energies produced by combustion to mechanically push, pull, spin, separate, sever, jettison structure, components or activate other functional systems.

Hi-Shear's controlled energy principle uses a small charge of low pressure type powder to achieve an instantaneous, mechanical action.

Standard electro-combustion hardware designed by Hi-Shear may be used, or the Hi-Shear controlled energy principle may be applied to custom applications you may have as exemplified by the release of external stores from aircraft, operation of undersea devices, time delay mechanisms, in-place tie-down in situ, stage separation or for a variety of applications on space vehicles.



CAPABILITIES A combination of Hi-Shear capabilities are offered: electronic and ordnance release of an experienced staff, design, manufacturing and quality control skills as a long established precision hardware manufacturer, as well as complete laboratory facilities for ordnance, meteorological, physical and environmental testing and instrumentation.

U.S. AND FOREIGN PATENTS APPLIED FOR

hi-shear

CORPORATION

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SEPARATION WEDGE
For solid separation, this flat end is used to combine with a standard flange, high strength aluminum ball or tin ball design alternative. Can be used in various configurations.



SLIP-ON SEPARATOR
Provides instant release of ring or similar type items. Also provides a separation interface to the above if hard to pull to free the system from the structure. Will carry full tensile loads of the parts.



SHOCK WOLF
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RAYTHEON

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MICROWAVE AND POWER TUBE DIVISION

Volume 77
Number 1

Aviation Week & Space Technology

July 2, 1962

National Aeronautics and Space Administration

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COVER: Base heating studies on Saturn model in Lewis Research Center tunnel

This special issue devoted to the vast expansion of the National Aeronautics and Space Administration's programs across the broad spectrum of space technology was written and edited by a special Aviation Week & Space Technology task force directed by Everett Clark, Washington Bureau Chief and AV&ST's first Space Technology Editor. The issue consisted of David A. Anderson, Technical Editor; Irving Stone, Wire Column Editor; Philip J. Kline and Henry Miller, Editors; J. Robinson and George Alexander, Space Technology Editors; assisted by William S. Reed, Arnold Sherratt and Ann Daugherty with art direction by Lawrence J. Herb, Art Editor. All of the NASA field centers were visited by this task force in the preparation of this issue, in addition to extensive briefings at NASA headquarters in Washington, D. C.

NASA's Spearhead to Space Creates New

This country is now straining into space at a pace very close to the full capacity of its available resources. At the same time it has embarked on a massive program to create the basic new resources required to further accelerate the current pace during the next decade.

National Aeronautics and Space Administration is now the spearhead of the U.S. space technology program and bears the heaviest responsibility for its ultimate success, although NASA is still heavily dependent on the resources of the aerospace industry and the military services. NASA has come a long way from the fall of 1958, when it was created by an act of Congress and signed into being by President Eisenhower—just about a year after the Soviet Union's Sputnik 1 marked the dawn of the space age. At birth, NASA was a loose amalgamation of resources hastily gleaned from the research laboratories of the National Advisory Committee for Aeronautics, the Naval Research Laboratory's Vanguard team and the Army's Jet Propulsion Laboratory. It had an overly modest budget and little top-level governmental support for its tremendous task of trying to overtake the Soviet Union's then commanding lead in space technology.

By mid-1962 this infant of 44 months ago has already grown into a giant with technical resources, budget and national priority commensurate with its Gargantuan task. It also has a clear goal on which to focus its major energies:

Lead men on the moon and return them safely to earth before the Soviets.

Despite the highest national priority for the manned lunar landing mission, this is not the sole goal of the national space technology program nor even the essential point of why this nation will probably devote more than \$50 billion of its tax dollars to this task during the next decade. Because the requirements for the manned moon mission encompass almost every vital segment of technology that must be mastered by any sound space program, it provides an ideal focal point for this vast effort along with the essential stimulus of a clear-cut goal and tangible achievement. It also is the first point in the history of space exploration where it is technically possible for this country to overtake the Soviets and beat them to this goal.

Although NASA's space exploration program is now focused on the moon, the knowledge gained from this effort will be reflected primarily in a better life for man on earth.

What can the U.S. citizen who is supporting NASA's effort with his tax dollar eventually expect from his investment in space technology?

• **First, it is providing a badly needed exercise in mobilizing national resources to achieve a basic national goal.** This is a capability the U.S. has demonstrated previously only under the stress of a shooting war. But with the basic change in international conflict wrought by the thermonuclear threat, this direction of a nation's specialized resources to express an essential national purpose should act, and indeed cannot, await the obvious stimuli of armed conflict. Organization and successful operation of a national space program will be a significant exercise of the leadership and flexibility required for survival as an entity in the modern world.

• **Second, it will explore a basic new scientific frontier that will produce a vast reservoir of new knowledge and technology that will have a profound and revolutionary impact on our economy, in much the same manner that the furious pace of research and development during the Second World War spawned the giant new industries that have sparked our economy through its amazing post-war growth.**

• **Third, it can provide an expression of national vigor and vitality measuring this nation's capability for international leadership at a time when this is sorely needed.** From its inception, NASA has heavily emphasized the openness of its scientific program and diligently worked with scientists of all nations, not only in sharing the knowledge gleaned from its own experiences, but assisting them to organize their own space research experiments and pursue their own specialized lines of study. Despite the initial, universally acknowledged leadership of the Soviet Union in space, NASA's open-minded international cooperation program, in contrast to the USSR's medieval secrecy regarding its own technology, has already made a significant impact on the minds of the international scientific community. Nobody who attended the recent Cospar sessions in Washington could miss the growing significance of this aspect of NASA's program.

It is a historic fact that the Soviet Union led the world into the space age with Sputnik 1 and that this country truly organized its own space technology program only under the tremendous international pressure generated by the Soviets' initial successes. At the time NASA was organized, few knowledgeable persons in this country or anywhere else would have bet that the U.S. flag had anything but the faintest chance of being hand-carried to the moon before the hammer and sickle.

Now we believe that this country has a better than even chance to win this laurel, and even if it

Capabilities, Markets

does not, it can certainly become pre-eminent across the whole broad spectrum of space technology as long as the present scope and quality of its program continues to reflect the current measure of public and governmental support.

President Kennedy established the manned lunar landing mission as the goal of a vastly expanded space technology program in May, 1961, little more than a year ago. Since then NASA has moved with a speed, vigor and imagination not usually found in government to organize, expand and enlist the necessary technical and industrial support to achieve the Apollo goal.

In mid-1962 it is possible to perceive the full pattern of these changes, the problems they present and the challenges they offer to science, industry and education. This is why AVIATION WEEK & SPACE TECHNOLOGY picked this particular time to assign a special editorial task force to a three-month study of the new NASA pattern and its potential for the aerospace industry, which is presented in this issue. Virtually all of the new NASA pattern is now complete and the outline of its major future problems clearly visible. The only piece still missing is the decision on which technical approach will get top priority as the major spearhead through space to the moon—lunar rendezvous or earth orbital rendezvous. Even this decision should be made before the end of July.

NASA has made remarkable progress in proving its operations to the accelerated pace and expanded goals of the Apollo program, but it still faces many major problems in the years just ahead. These include:

• **Personnel.** NASA is successful in attracting recent college graduates with the bait of opportunity to complete advanced degrees while working on the latest technologies. It has also attracted some good men from industry with the lure of directing major new programs, but it is having trouble ingesting the large quantity of experienced engineers and scientists in the ranges where industry salaries are much higher and NASA job challenges are not overbidding considerations. NASA already has gone to industry to fill two key requirements originally scheduled for in-house capability in the Hellman system plotting contract and the General Electric Apollo system integration and quality control contract.

• **Technical gaps.** Major technical gaps must be filled in various areas of the space technology spectrum such as high speed recovery, orbital rendezvous, bioastronautics, radiation patterns, etc., before the full firm foundation for Apollo can be

built. NASA faces the problems of filling these major technical gaps at the same time it is designing hardware for the lunar mission.

• **Military interface.** Few of the knotty problems of organizing and operating an effective NASA military interface have been tackled yet, although increasing emphasis is being given to this area. Still unresolved is how much the military requirements in space will influence NASA's research and development programs and how much military support NASA can expect for its future efforts.

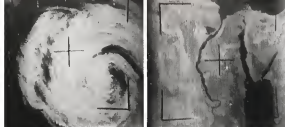
• **Public and congressional support.** Congress has supported the \$3.4-billion NASA budget for Fiscal 1963 with an unprecedented unanimous vote in the House. Overwhelming endorsement of this budget is also expected later this month from the Senate. But as NASA programs progress, funding requirements inevitably will rise considerably above early estimates and it is likely that the agency will have to ask Congress for support in the \$6-billion area for future years or face a significant reduction in its program operations. To get sustained support over the next decade from both Congress and the taxpayer public at this level will require both an unchallengeable superior performance by NASA and a thorough understanding of its operations and achievements by the public.

For industry, the expanding NASA program offers new markets and presents many new challenges. It will require management alert to the rapidly shifting tides of technology and technical capabilities to exploit them in a highly competitive environment. It will present management with new ground rules in procurement, proprietary rights and profits and it will present industrial technology with new standards of reliability, design and production.

In looking over space technology in the summer of 1962, after visiting most of the NASA research, development and test centers and many of the great industrial complexes that support them, it appears that an ineffable spirit is stirring in the land. It is attracting the mentally adventurous and youthfully bold to this exploration of the universe in much the same spirit with which the ships of the late 15th Century mariners were moved to explore the western oceans.

Like these ancient European mariners, who never achieved their goal of a shortcut to the Orient but opened the Americas instead, the space explorers of this generation may find their real achievements in areas that cannot be seen from this point in time on the earth's crust beneath its atmospheric sheath.

—Robert Hite



CYCLONIC STORM area, left, photographed by Tins 5 which was launched last June 19, disintegrated almost nine hours after launch by these experimental NASA meteorological satellites. Tins 5 photo at right shows Lake Rona, near Conakry, Guinea.

Manned Lunar Program Reshapes NASA

Decision to push Apollo expands size and cost of agency's effort, strengthens its reliance on industry.

Washington—Milestones to attempt the greatest engineering feat ever undertaken by man—landing men on the moon and bringing them back to earth—has shaped and changed the National Aeronautics and Space Administration until it can almost be considered a new agency undertaking a new program.

Manned exploration of the moon and planets has been implicit in NASA's mission since it was created. But until the Apollo lunar program was announced by President Kennedy on May 25, 1961, NASA was not specifically beyond Project Mercury.

The Apollo decision greatly expanded the size and cost of NASA's program, caused an internal reorganization, forced a strengthening of the agency's relationship with Defense Department and a reorientation of its dependence on industry, cut its relationship with Congress in no uncertain way and sharpened its attitude toward new projects as always less sure of success.

Manned space flight now represents one-half to two-thirds of NASA's total effort. The civilian space program has more goals and more from the lunar mission. But Apollo is affecting even these, by forcing lunar scientific projects into queue of a supporting, then a purely exploratory role, for example.

Although change and growth are the norm in any dynamic institution, NASA's evolution in the past 13 months has made its earlier years seem peaceful.

NASA asked the Congress this year for \$3,787 billion in Fiscal 1965 funds and a supplemental Fiscal 1963 appropriation of \$156 million. The 1965 figure is more than double previous year's budget, which in turn was 16 times that of the last budget requested by the old National Aeronautics Administration for Aeronautics for 1949.

Requested increase in headquarters

post, that the overall program needs support. The latest will be no small task, since the projected cost of the space program over the next 10 years is \$15 billion, with about \$30 billion allocated for manned flight.

The tremendous cost and low production rate on launch vehicles, spacecraft and components—some of which must function in perfectly that rate can rely on them for their lives at a distance of 240,000 mi. from the earth—have led NASA to institute a rigorous qualification program that is requiring stringent inspection by NASA and extensive inspection and detailed reporting on schedule procedures by prime contractors, subcontractors and suppliers (see p. 140).

NASA also must continue to look for flexibility and improvement in its management, something it has done continuously since it was created on Oct. 1, 1958. And a must today the Congress, which it has not done yet, but it has solved all the major technical problems between the civilian and military space programs.

NASA research, development and operations work is carried out by eight major centers, the California Institute of Technology's Jet Propulsion Laboratory, and five smaller offices or institutions (see p. 76). The organization has grown from about 8,000 NASA employees and a handful of Navy personnel from the Vanguard and Argus air research groups in late 1955 to 21,880 at the end of Fiscal 1962 and is expected to increase by almost 4,000 in this fiscal year. These figures do not include JPL, which is a contractor.

About 32% of NASA's total employment in the recent past has been scientists and engineers, but the current goal

is about 35%. The theory is that bringing more people with these skills into NASA will do more to conserve U.S. technical manpower than anything else, since NASA must manage such large technical projects with industry.

Last November, NASA began a recruiting drive for technical employment—specifically engineering—that was to cover 30 cities. By early March, NASA had made 800 offers and 37% had accepted. Albert F. Supert, NASA's director of administration, called that "an indication of acceptance rate in view of industry experience." NASA is less concerned at this point about its own recruitment problems, in which it needs about three-fourth engineers, as it is about the academic area generally.

Assistant Administrator Robert C. Seamans, Jr., told Congress last month feeling that "we are somewhat weak in the scientific area and I think, if you look ahead we've got to make strenuous

efforts in this country to augment the number of really capable scientists that we have." NASA attempts to help in this through space science programs with universities.

A great portion of the management of NASA's technical projects is handled by the centers themselves. Headquarters hasn't itself chafed to the management of overall programs attempting to coordinate the NASA approach at decentralization.

NASA's Office of Manned Space Flight is an exception to this rule, in which more work, and although the advent of Apollo was not the sole reason for the organization that created this office, it was the key one.

When President Kennedy took office early last year, all agencies were asked to reexamine their budgets, which had been dismantled, while the previous Administration was in power.

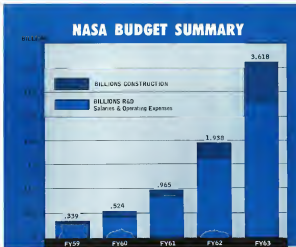
The 1960-1965 response to this

was to pose two major policy questions: • **Should the U.S. now clearly behind the Soviet Union in space programs, should it accelerate the development of large boosters?** Estimated price tag for doing this was \$100 million for the first year.

• **Did the new Administration want to reaffirm the old Administration's decision not to go beyond Project Mercury, or reverse it?**

The President asked NASA to turn these questions into recommendations. He accepted the first almost unthinkingly and suggested a supplemental appropriation for boosters late in March of last year. The second recommendation produced a great deal of discussion, involving members of government, science and industry, and involved itself into a question of when and where the U.S. could catch Russia in manned space flight.

The conclusion was that Russia is



NASA BUDGET picture shows rapid growth since its creation. Fiscal 1963 figure is that authorized by House space committee. Full House voted \$3.7 billion. Senate space committee has voted \$4.5 billion. Appropriations committee has not acted.

NASA INSTALLATIONS

MINITRACK STATIONS

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Fl. Myers, Fla.
Orlito, Ecuador
Lima, Peru
Antofagasta, Chile
Santiago, Chile
Woomera, Australia
Eskine Park, S. Afr.
San Diego, Calif.
St. John's, Newfoundland
E. Grand Forks, Minn.
Fairbanks, Alaska
Worfield, England

*To be relocated to
Goldstone, Calif.

MERCURY TRACKING STATIONS

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Brevard
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Grand Canary Island
Kono, Alaska
Zanzibar
Indian Ocean Ship
Perth, Australia
Woomera, Australia
Canton Island
Reno
Pt. Arguello, Calif.
Guaymas, Mex.
White Sands, N.M.
Cape Canaveral, Tex.
Clyn AFB, Fla.

MINITRACK STATION
East Grand Forks, Minn.

LEWIS RESEARCH CENTER
Cleveland, Ohio

LIAM BROOK RESEARCH STATION
London, Ohio

SEDGWICK SPACE FLIGHT CENTER
Greenbelt, Md.

NASA HEADQUARTERS
Washington, D.C.
MINITRACK STATION
Blount Point, Md.

LANGLEY RESEARCH CENTER
Langley Station, Hampton, Va.

Wallops Station
Wallops Island, Va.

DATA ACQUISITION FACILITY
Houston, Tex.

MURPHY SPACE FLIGHT CENTER
Huntsville, Ala.

MISSISSIPPI TEST FACILITY

MERCURY TRACKING STATION
Clyn AFB, Fla.

MAINED SPACECRAFT CENTER
Houston, Tex.

LAUNCH OPERATIONS CENTER
ATLANTIC MISSILE RANGE
Cape Canaveral, Fla.

RICHARD FLINT
Midland, La.

MERCURY TRACKING STATION
Clyn AFB, Tex.

MINITRACK STATION
Fl. Myers, Fla.

HIGH RANGE TRACKING STATIONS

NUCLEAR ROCKET DEVELOPMENT STATION
Jensen Field, Tex.
NASA—AED

MERCURY TRACKING STATION
White Sands, N.M.

FLIGHT RESEARCH CENTER
Edwards, Calif.

SLICK, Wash.

PACIFIC MISSILE RANGE
Pt. Arguello, Calif.

WESTERN OPERATIONS OFFICE
Santa Monica, Calif.

JET PROPOSITION LABORATORY
Palmdale, Calif.

COLLIERVILLE TRACKING STATION
Goldstone, Calif.

DEEP SPACE INSTRUMENTATION FACILITY
Goldstone, Calif.
Woomera, Australia
Johannesburg, S. Afr.

AMES RESEARCH CENTER
Moffett Field, Calif.

NATIONAL AERONAUTICS AND

SPACE ADMINISTRATION





Dr. KUNIO HIRASAKA, MIT, chief scientist of Robo-Rosetta Laboratory, and Toshiro Matsuda of Yokohama Electric Co. participated in joint Japanese-U.S. tour at Nike-Capri sounding rockets from NASA's Wallops Island, Va.

NASA Spurs International Space Efforts

Washington—Broad but highly selective program of international cooperation involving more than 35 nations is rapidly and quietly spreading the scientific benefits of space research and proving the openness of the U. S. civilian space program to the free world.

Even the Soviet Union has shown an inclination in recent weeks to consider cooperative projects, after almost four years of refusing to deal with anyone including the Communist satellite nations.

True to a strong belief in the National Aeronautics and Space Administration that the change in Russia's attitude is a direct result of the highly successful program NASA has built for the U. S., which has included participation by the same Communist nations that Russia rebuffs.

Neither the extent of U. S. space ventures with other nations nor the hard-headed practicality of the program is appreciated widely in this country, NASA believes. Not less the aerospace industry fully realized the scope of the potential market that broad participation by free nations could produce outside its own country.

More than 46 nations are directly involved in cooperative projects such as

scientific and sounding rocket launches, ground-based meteorological observations related to U. S. weather satellite flights, and communications with the spacecraft.

Early this is so are involved in technical support for Mariner, Mercury and deep space tracking networks—with some countries joining for and receiving the stations themselves and sharing data with the U. S. About 30 countries are engaged in NASA-sponsored educational and training programs, which include a year of study in the U. S.

More than 1,000 scientists and government officials from more than 30 countries visited NASA headquarters last year, and that number is growing as participation expands.

This year, for the first time, members of the United Nations Committee on the Peaceful Uses of Outer Space visited Cape Canaveral. They were invited in groups of NASA and the U. S. to witness the world's first cooperative satellite launching of the people—the U. S.-United Kingdom Aqualion satellite.

Delegates to the third annual meeting of the Committee on Outer Space Research (COSPAR) of the International Council of Scientific Unions—including some delegates from Iron Curtain countries—took advantage of the Washington meeting site to visit NASA's nearby Goddard Space Flight Center and the Wallops Station at Wallops Island, Va., where NASA and pre-project sounding rockets are launched.

More important than the breadth of the cooperative program is its insistence on quality. The decision to enter a joint project through an agreement with NASA's Office of International Programs must be the other country's, and the ground rules are strict.

•No dollar exchanged NASA does not insist on equal expenditure of dollars, but each side must finance its own contribution.

•This is much more meaningful than if we subsidized the whole program," Marvin W. Robinson, deputy director of the international office, said. "First of all, the other country should know it has to be able to afford what it's getting into and second, it can make as many or as few as it knows how, so that it is a truly cooperative program."

•Experiments must have purpose of producing a meaningful scientific contribution and must be of mutual interest. "We are not interested in just supplying rockets," Robinson said. "This does not mean that NASA expects a country substantially of its space technology is not as advanced as that of the U. S. that would defeat the purpose of the international program."

In Pakistan's case, for example, mutual talks between U. S. and Pakistan scientists indicated that Pakistan was not yet technically ready for a joint experiment. NASA trained Pakistan scientists and technicians at Goddard, Wallops, and two universities. Then it sent a technical team to Pakistan to help select a launching site, and provide a Nike-Capri sounding rocket for a sounding vapor experiment. The Pakistanis installed the equipment, ran the range, etc., and last June 7 the Nike-Capri—commanded Robert J. Temple—the first Pakistan space flight from a site near Karachi. Several more experiments in the joint project are due over the next few months.

"This is cooperation in depth," Robinson said, "not just an exchange of hardware."

•Joint projects are completely open. All U. S. agencies are with civilian agencies, designated by the other country's government so that NASA does not become entangled in domestic disputes between rival space organizations, and the data gathered must be made available to the scientific community. All agreements so far have been between NASA and a single government organization with the exception of Yugoslavia, a paragonized and paragonized organization created in Italy for participation in a communication satellite experiment.

NASA is not trying to sell or push this data anyone else's piece," Robinson said. "The impact has to be felt. We just don't tell them, it is no secret in doing an experiment and getting. We are trying to attract but we are not subsidizing."

Word on the joint program is as changed through visits of U. S. scientists to meetings abroad and vice versa, through U. S. information channels, and so on. U. S. embassies are involved with details on the friendship programs "but with careful instructions that no one is to beat the drums," Robinson said.

"There is no need to get involved with countries that cannot afford a project or haven't the scientific competence—and yet we have the most number of participants that we do, and the number is growing."

Industry Interest

Increasing interest by U. S. aerospace firms in recent months has led NASA to believe that the industry is beginning to appreciate the significance of the international program.

"The potential market for rocket and satellite hardware, electronic flight and ground equipment, range instrumentation, payloads, etc., is a large, new market. If other countries want to use their own manufacturing which can have indicated they do, they are often



MERCURY parking station at Kono, Nigeria, typical NASA's cooperative projects.

interested in the possibility of cross-linking agencies.

NASA can offer little specific assistance, beyond information, which other countries are involved in programs and explaining what its own role is, since other government agencies handle such problems as export licensing. But the International Programs Office is clearing about one out of a week from firms that are ready to send sales representatives abroad to explore the market potential, and Robinson recently was asked to speak to an Aerospace Industries Association group about the scope of the cooperative program.

Practical Advantages

NASA recognizes the obvious potential advantages of having a completely open program being to draw money and to an organization created as a civilian agency for the peaceful exploration of space. Scientists both the Americans and the Russians administrators have recognized that the program is only worthwhile—once from the practical point of view of real scientific contribution as made.

"We can never be accused of using a cooperative program for purely political gain," Robinson said. "When a scientist from a cooperating country gets up at a meeting abroad to report in a scientific field, it is partly due to fellow scientists to question whether the experiment has been a useful one. We would be a disservice to both countries if we use cooperative programs."

These are practical reasons other than political for joint operations.

•No nation has a monopoly on brain power, and the problems and questions to be answered are transnational, Robinson said.

"We want to have it more people as possible involved, especially if what is desired is to have its application beyond basic science."

Though an agreement with Sweden, NASA will provide four Nike-Capri for four flights from the Vidar Range late this summer that will sample near-shore clouds. Origin of these very high, fairly horizontal clouds is unknown. This comes only for a short period of the year and only in certain regions of the annual cycle.

Last April 24, the first of three Nike-Capri was launched from Wallops Island in a joint U. S.-Japanese test of a Japanese developed radio frequency resonance probe that may permit measurement of electron density and temperature simultaneously with only one instrument, and at a faster rate than before.

Experiments such as these obviously give the U. S. program a scientific advantage that it would not have only and joint programs.

•Strong in the U. S. together. The best example of this has in the communication satellite field. The U. S. would like to conduct intensive experiments with the NASA American Telephone & Telegraph Ticker satellite and its own Alouette satellite. It undoubtedly could have obtained permission to build large antennas. But the interest in other countries is as high as it is here. France is building a new \$12 million station and England is building one at a cost of \$3 to \$4 million. These agreements with NASA call only for cooperation in research and development, with no commitments regarding an eventual operational mission.

Through such agreements, England,



UN SPACE COMMITTEE inspects UK 1 satellite at Cape Canaveral, Fla.



NASA's Peter Mueller takes visits data equipment being at Aberdeen, Idaho.

France and Britain probably will be needed for the first experiments this summer. Germany is building a sounding and receiving station, Italy is contributing a receiving station and NASA is discussing joint ventures with other countries. A great number of countries are interested, if for no other reason than the revenue that such systems are expected to produce. But cost and such technical limitations as the coverage the satellite will give, and the power supply it can carry, will hold down the number of participants.

Satellite Workshops

NASA and other government agencies recently sponsored an international communications satellite workshop, similar to the successful international meteorological workshop that attracted representatives of 27 nations to Washington last fall. The agency paid no travel expenses, but representatives of some 30 countries attended.

In addition to covering broad subjects and techniques at its research centers for specific projects such as the Palisades experiment, NASA has two

programs administered for it by the National Academy of Sciences.

- **International fellowship program**, in which other countries select young graduate students to attend one of 15 leading U.S. universities engaged in space-related research. Applicants' qualifications are reviewed by both the university and the university. The other country provides the U.S. and reimbursement for a non-scientist. The program is not a U.S. subsidy—and NASA pays tuition and related travel costs for visits to NASA centers. The pilot program so far has included seven fellows from six countries and has been so successful that it will be expanded next fall. The European Space Research Organization (ESRO) already has set aside 15 fellowships to be used in this program.

- **Resident research program**. Under this plan, carefully selected senior scientists from both the U.S. and abroad work for one year as either faculty or experimenters at Goddard or Goddard's Institute for Space Studies in New York City. In this case, NASA provides, through the university, a stipend contract with the scientist's senior status. NASA also is responsible to invite scientists for U.S. scientists. A. R. Jorgensen, NASA's deputy administrator, Dr. Hugh Dryden, produced some hope that Russia may eventually cooperate in space research.

Program Administration

All aspects of the international program are administered by NASA's satellite office, Office of International Programs, under Director Arnold W. Fritts. The office consists of only 19 people, including scientists. It draws legal and technical help from other NASA offices and centers, and most of the actual operations involved in joint agreements takes place at the field level—chiefly at Goddard and Wallops. This office also coordinates with State Department, the Weather Bureau, the airlines and other organizations.

ESRO, which has a membership of 10 European countries and is the first example of regional cooperation in space research, has sent groups to the U.S. to study NASA's methods. NASA can deal with ESRO as it would with a single country, but it retains the privilege of bilateral agreements with member nations and as member nations of ESRO retain the privilege of conducting their own research programs.

NASA expects this regional cooperation approach to grow—possibly as South America goes—and expects greater participation from member states for specific projects such as the Palisades experiment, NASA has two

so far has been completed only with the United Kingdom and Canada—chiefly because cost and competence are formidable barriers. But the preparation of the large observatory satellite (see p. 18), which can carry a number of experiments, may permit other countries to send up single experiments. They would be subject to the same safety and security restrictions imposed by NASA, university and other by government law.

Participation in NASA's space work has included Czechoslovakia, Hungary and Poland. All three have made considerable ground observations of Tson weather satellites at the invitation of NASA and the Weather Bureau.

Series Situation

Recent talks in Geneva between Soviet and U.S. scientists, A. R. Jorgensen and NASA's deputy administrator, Dr. Hugh Dryden, produced some hope that Russia may eventually cooperate in space research.

A joint observatory (used by Dryden and Jorgensen) and that recent operations had been demanded to both governments for cooperation in meteorology, a world magnetic survey and satellite telecommunications, "looking into the future" and "looking into the past" of meteorological satellites, and possible coordinated launchings of satellites by each country for the magnetic project.

Fritts pointed out in a speech some time ago that the International Geophysical Year, often cited as an example of world-wide scientific cooperation, was in fact a collection of national programs barely coordinated by a non-governmental mechanism, that it did not solve any political problems, that "Soviet antagonism greatly restricted the IGY agreements for exchange of information" in space research, and that Russia "has effectively blocked a purely scientific cooperation in space research under UN auspices in order to exact a political price which would give it a veto over the activities of other nations in entering the problems of outer space."

But the Geneva talks—follow-up to exchanges of views by President Kennedy and Premier Khrushchev—have at least opened the possibility that Russia has learned a lesson. If it has, near-term U.S.-Soviet talks on the first international program was the teacher.

NASA Seeks to Enlarge Space Benefits

Washington—National Aeronautics and Space Administration has moved beyond its communication and meteorological satellite research (see p. 18) and 1961 to begin a modest program of exploring low-technology ways to apply the benefits of space technology to the national economy.

President Kennedy told the Congress last January that "all of us in the United States and in all nations can derive many benefits from the peaceful application of space technology. The impact of this new science will be felt in our daily lives."

"It can bring all people closer together, through improved communications," the President said. "It can help control the chronic drought in the United States. We can safely predict that the impact of the space age will have a far ranging effect within industry and in our labor force, in medical research, education and many other areas of national concern."

NASA has formalized its approach to this by creating a directorate of its top applications under its headquarters Office of Applications, which is headed by Norton J. Slichter.

One program now in the planning stage calls for study of civil applications of the Navy-developed Transit navigation satellite, including the feasibility of its use by civil aircraft and ships. Slichter emphasizes that NASA has no intention of duplicating current Navy efforts, nor does it see the need for a separate civil navigation satellite. The Navy already has under development a reduced-accuracy, lower cost receiver for use with the Transit which the space agency hopes to evaluate for civil applications.

Another possible satellite application now under consideration is a general purpose data collection approach that might be

used to obtain data from a variety of different terrestrial sources. For example, the Navy might be interested in placing self-powered buoys at key points in the ocean to measure the sea state, while the Weather Bureau might be interested in small unattended weather stations placed at remote sites in the Arctic and Antarctic whose measurements could be teletransmitted to a general purpose data collection satellite for subsequent transmission to data collection stations.

Applying Knowledge

The principal problem coming out of NASA's program will be new knowledge—knowledge of the space environment, the solar system and the earth itself. While this will be valuable and extremely useful to the world's scientists, its impact on the peoples of the world probably will be limited, at least initially.

But the new technologies and innovations, spurred by the needs of NASA's space program, are certain to have a more dramatic impact on industry, and through its products, on society as a whole. Since any new invention or advance

in the state of the art usually is a product of knowledge gained from many sources of information, it will not be easy to pinpoint those which result solely from NASA's efforts and program, particularly since much of the technology which NASA uses today is a direct outgrowth of military research and development.

A few examples of such advances, whose lineage is difficult to trace but whose impact on our lives, non-space activities appears promising, are cited.

- **Photocopying**, developed in the early 1950s for use in rocket fuels, has spawned a family of drugs for mental illness, for treatment of ingrown toenails and subconjunctivitis.

- **Fluorocarbon** propellant systems, first applied by Jet Propulsion Laboratory in the manned case used as casing self-propelled rocket nozzles to enable the spacecraft to be withdrawn later without sticking and without contamination of the propellant reservoir, is now being applied as a release mechanism in probes used to penetrate the planet, to fracture glass chips and to release pocket watches, according to Leon B. C. Fong, chief of industrial applications in the office of applications.

- **Magnetic pulse welding**, employed in fabrication of the Saturn launch vehicle at the Marshall Space Flight Center, uses one of strong magnetic fields to shape metal. Electrical energy equivalent to \$5,000 - 10,000 ft-lb., stored in banks of capacitors, is discharged into an induction coil and is then the equivalent of a second, generating a tremendous



MAGNETIC PULSE welding technique being perfected at Marshall shapes metals by dumping extremely strong electrical charge into induction coil. Magnetic field pulses metal against the Puma for Saturn booster are being formed this way.



MARSHALL TECHNICIANS place the around segment of propellant line for Sotom, left, ensure it after metal is formed by magnetic field.

magnetic field which pushes steel against a forming die.

Stanley gas heater, a new heating device developed by NASA's Ames Research Center, may find a variety of industrial uses where chemical reactions must be carried out at extremely high temperatures. The heater has two doughnut-shaped, water-cooled, copper discoids which are coated to spin at 480 rpm by the application of an external magnetic field while a high intensity arc is drawn between the two spinning electrodes. The spinning generates electrode heating and the energy of the arc is transferred to the gas or molten in which they spin. Operating at pressures up to 2,800 psi, the heater can heat gases up to 1,000 deg and provide enthalpies up to 3,000 Btu/lb.

Speedy Application

Such new techniques and developments provide first speedy application throughout the aerospace industry, Stoller says, as a result of trade publications and technical conferences. But a major objective of the NASA future applications program is to derive effective means for bringing these new techniques to the attention of companies outside the aerospace field, for application to industrial and consumer products.

NASA recently has formed a small group at each of its research and development centers whose assignments are to familiarize themselves with new techniques, processes, materials and devices being developed or applied in their respective facilities.

This will involve close liaison with branch chiefs and individual engineers and scientists as well as with NASA's patent lawyers. Stoller says that ideas which are not patentable may nevertheless have sufficient novelty to offer benefits to industry users.

The applications group at each cen-

ter will file periodic reports on new ideas and techniques to NASA headquarters, where they will be stored and disseminated by the Office of Technical and Scientific Information. The first quarter reports are now beginning to come in, Stoller says.

Stoller said NASA is attempting to seek out areas wherein its outside contractors would also be required to file reports on new techniques.

The problem of how best to disseminate such information to companies outside the aerospace field is under investigation. NASA has contracted with the Midwest Research Institute, which serves industry as the Kansas City area, to conduct a pilot effort to transfer new techniques coming out of the aerospace field to Midwest companies operating in other fields.

The institute first had its researchers visit major NASA centers and compile a list of about 35 conspicuously new techniques not previously known or applied outside the aerospace field. For the past several months, MRI has been visiting major cities in the Midwest, holding seminars to brief local firms in these techniques.

As a result of such seminars, one local manufacturer who was experiencing difficulties in separating blocking molts from salt because the felt stuck to the mold, learned of the use of Teflon to prevent parallel sticking in molding and saved considerable costs. The company now coats the blocking mold with Teflon and thereby eliminates its previous troubles.

The institute will check later with sales individual manufacturers to see how many are applying ideas learned at its seminars.

But NASA is not overlooking the need for the effective interchange of new technical information among its own scientists and within the aerospace industry itself.

The space agency recently awarded a \$1.4-million contract to Documents, Inc., Bethesda, Md., for the creation and first year's operation of an integrated technical information center to disseminate information to NASA scientists, its prime contractors and to other designated organizations and scientists.

The new scientific and technical information facility is expected to receive, catalog and file in miniature photographic form more than 25,000 reports a year from NASA centers and contractors. The facility will use an IBM 1401 for automatic location and retrieval of information.

Biweekly Publication

All documents registered at the new facility will be abstracted, and the abstract will be published in a biweekly journal, "Technical Publications Annotations," to be prepared by Documents, Inc. and issued by NASA. Quarterly, semi-annual and annual cumulative indices will be published.

The new facility is intended primarily for use by NASA's scientists and its contractors. While the catalog will be distributed at the rate near Washington, the facility will supply duplicate computer tapes of its catalog to each NASA center and to individual organizations participating in NASA programs, so that location of desired information can be carried out on a decentralized basis.

Copies of all reports received by the new facility will be sent to each NASA center and to participating contractors either in original printed form or in 5 x 8 in. microperforated sheets which can be used either in optical viewers or to make photo reproductions.

The new facility is operating under the direction of NASA's Office of Scientific and Technical Information, headed by Melvin S. Day.



Apollo command module and escape tower mounted in Ames Research Center tunnel

Manned Space Flight



RENDEZVOUS CONTROL: *By Astronaut*

Primary control responsibilities during Gemini rendezvous and docking operations will be assigned to the Astronauts Man, with his ability to see, analyze, reason and judge, will be fully utilized for this important phase of America's first spacecraft rendezvous operation.

Gemini is a two-man, extended mission, orbital rendezvous and docking spacecraft now being designed and built for the National Aeronautics and Space Administration by McDonnell.

Rendezvous in space can have several applications

in speeding America's space exploration efforts. Rendezvous will permit launching of multiple payloads with two or more smaller boosters rather than one large vehicle. With such techniques it will be possible to assemble large space stations, ferry space crews and supplies, refuel and/or assemble chemical upper stages for deep space missions, and refuel reusable nuclear upper stages for deeper space explorations.

Space Rendezvous, the key to a quickened pace in manned space exploration, is another facet of manned space flight being pioneered by McDonnell



APOLLO WOODEN MOCKUP under construction in North American Aviation's Downey plant.

NASA, Industry Facing Apollo Challenge

Nation guards management and technical resources; most complex peacetime job has \$20 billion estimate.

Washington—Awareness that landing a man on the moon and returning him to earth is the most challenging peacetime undertaking in the history of the U. S.

Project is complicated by the pressures of a tight timetable that will tax the ingenuity and manpowerfulness of much of the nation. At this point in the development, beginning to manage the program is as difficult as the technical complexities which the program itself faces.

Project Apollo, and Mercury and Gemini in its precursors, have become the focal point for a significant portion of the country's scientific and technical effort. An estimated 100,000 top government industry and Defense Department personnel must be mobilized into a single team to assure success of the manned space flight program.

Project Apollo, and Mercury and Gemini in its precursors, have become the focal point for a significant portion of the country's scientific and technical effort. An estimated 100,000 top government industry and Defense Department personnel must be mobilized into a single team to assure success of the manned space flight program.

Despite its anticipated \$20 billion cost and the unprecedented effort it demands, Apollo is only a start in man's exploration of space. It is certain to be followed by manned probes into deep space and planetary exploration. Effective management of the program demands precise planning and the coordination of the resources of the nation. The decision maker. Whether this, the nation in dollars and talent will be monumental because nothing is new in a manned space flight. But the potential fallout from the program is monumental, too. The first step in space exploration has become the primary point of comparison between the U. S. and Soviet Union, and it is an area in which the U. S. can demonstrate its full capabilities.

National Aeronautics and Space Administration has chosen heavily as a duty to establish the framework for its manned space flight management responsibilities, both in management and

personnel. The program is a huge task. It is a job that is being reinforced on countless aspects of the program by working closely day to day with Glantz and his team.

The national management philosophy, according to Shea, is that "Washington does the major work, Glantz does the cap."

William W. Rogers, director of Launch Vehicles and Propulsion, performs the same function in local quarters' relationships with Marshall

Funding Requests

Washington—National Aeronautics and Space Administration has requested \$2.2 billion to conduct the manned space flight program in Fiscal 1963, which includes \$1.6 billion for research and development of spacecraft and launch vehicles and \$645 million for construction of production, test and launch facilities.

Of the total NASA proposed total of \$2.2 billion requested in Fiscal 1963, \$1,627 million is allocated to spacecraft and launch vehicle projects for manned space flight.

The funding breakdown shows:

- Manned spacecraft: Mercury, \$173 million; Gemini, \$1,312 million; Apollo with launch vehicles, \$617.5 million; Titan, \$112.5 million.
- Launch vehicles: Saturn C-1, \$1,049.1 million; Saturn C-5, \$1,316.2 million; Nova, \$267.5 million.
- New construction: Altitude Module, \$160 million; Altitude Module, \$160 million; manufacturing engine facilities and control center, \$78.5 million; Marshall Space Flight Center, \$134.4 million; Manned Spacecraft Center, \$107.7 million; and McDonnell manufacturing plant, \$18.4 million.

MCDONNELL

F-104 and F-105A Fighter and Attack Aircraft • RF-105 Reconnaissance Aircraft •

Mercury, Gemini, Atlas and Aeronautics Spacecraft • Nike and Titan Missile Airframes and Engines • Electronic Systems • Automation

MCDONNELL AIRCRAFT • ST. LOUIS

NASA Manned Spacecraft

Project	Spacecraft Contractor	Launch Vehicle	Spacecraft Weight (lb.)	Re-entry Vehicle Diameter (ft.)	Height (ft.)	First Flight
Mercury						
Thrustcraft (See-also)	MAC	Atlas B (B-4)	4,300	32	32	7/16/60
One-way			4,100	30	30	Feb 61
General			4,300	32	32	Early 63
Redoubtable						
See-also	MAC	Titus 2 (Atlas)	7,300	44	100	Early 64
General			6,400	44	100	Early 64
Apollo						
See-also	NAA	Saturn C-1	38,000	124	124	1968
General			40,000	124	124	1968
Orion						
See-also		Saturn C-5	330,000	124	124	1968
General			300,000	124	124	1967
Orion						
See-also		Saturn C-5	330,000	124	124	1967
General			300,000	124	124	1967

Abbreviations: MAC, McDonnell Aircraft Co.; NAA, North American Aircraft; Space Systems Division, GDC, General Dynamics; Aerospace.



ONE-EIGHTH SCALE MODEL of the Orion Orion manned spacecraft with its re-entry vehicle shown modular concept which is debuting the design of this space-age concept. Twelve Orion vehicles will be built by McDonnell Aircraft Co. to test reentry technology and to study ability of man to function after being exposed as long as 14 days. After direct ascent the capsule will permit easy pod checkout and parts replacement.

Space Flight Center and the Launch Dynamics Center at the Atlantic Missile Range.

Holmes' management organization also includes an Aerospace Medicine Directorate, headed by USAF Brig Gen Charles H. Rodehorst, director of Integration and Checkout, headed by James E. Shaw, and director of Program Review and Resources Management, headed by William E. Loh.

Detailed policies and technical design to conduct the manned space flight program are formulated by Holman, but are directed and by Gillett and Walter C. Wilburn at the Manned Spacecraft Center, Wenden Air Force Base and Edward R. Rusk of Marshall Space Flight Center, and Kent Deane of the Launch Operations Center. Together, they form a Management Council which meets monthly to discuss and resolve interface problems between spacecraft and launch vehicle and their support.

Pre-flight Certification

The certification program is being completed by various major contractors because of a projected certification NASA was unable to complete the type and number of people it wanted in the face of the schedule which has been dictated for the program. A number of Bell Telephone Laboratories and Western Electric, called Bellcom, is furnishing mission integration support for De Shaw, and General Electric will support Shaw in checkout, integration and schedule management.

It is within this framework that the vital management decisions are being made in mission planning for manned space flight, in contractor responsibilities being assigned for spacecraft and launch vehicle and in developing facilities for the suborbital test and launch of the vehicle to transport man to the moon and planets.

Houston Center Builds Broad Competence

New facilities to be completed in 1964 for central management, testing of manned spacecraft systems.

Houston—Development and operation of manned space vehicles is the responsibility of National Aeronautics and Space Administration's Manned Spacecraft Center, which is being built here as one of the first space development centers to have facilities completely compatible with its mission at the outset.

The center does not face the same difficult period of adjustment experienced by other NASA laboratory complexes when the agency's emphasis shifted from aerodynamics to space. When construction is completed in mid-1964, the U.S. will have a new competence to solve the specified spacecraft problems of manned flight to the moon and planets.

During the period the center is under construction on a 1,600-acre site 20 mi. from downtown Houston, technical and administrative functions are being carried on by a staff of 1,640 from eight buildings around the city.

The organization to develop spacecraft is being built around project offices, one for each of the spacecraft projects—Mercury, Gemini and Apollo. Development responsibility is a division function, with branches performing tasks in pre-flight operations, flight operations, and flight crew training and preparation.

Research and Development Division gives the center a capability to support the three projects directly and to explore the field ahead for development of future spacecraft. Engineering Support Division will provide mechanical test and data services for spacecraft bulk plates and models, data computer tests and checkout test services and engineering and design services.

The Administration Division provides the standard management, financial and facilities services with one exception. The center will develop into NASA's largest autonomous element in terms of dollars obligated. The fiscal 1963 total will be \$300 million, and it will grow to more than \$1 billion in fiscal 1964.

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Manned Spacecraft

Houston—Manned Spacecraft Center being built here has reported an operating budget of \$110 million for fiscal 1963 and an increase of 1,600 employees to bring the total to 2,700. While the center is under construction on a 1,600-acre site adjacent to the Lyndon B. Johnson Space Center, employees come from eight downtown Houston office buildings.

The center was authorized in fiscal 1962, and reports during the first two years its facilities will give it a plant value of \$90 million.

Project Offices

Because of the future mission aspect of Houston operations directly supports several projects, four of which at the new center will be the project offices. The four divisions will fill the following data into the project offices.

• **Research and development** spacecraft systems life history and physical characteristics, and system test and evaluation.

• **Operations** preparation of the spacecraft, including modifications, final all systems tests, altitude chamber tests, simulated flight, battery installation, protection backup, rocket alignment and weight and balance checkout.

Flight operations are divided into four distinct phases: final checkout, operations and launch flight control, mission management and medical monitoring, crew communication, recovery and abort, and mission termination and data acquisition.

Paul E. Pitzer, special assistant to Robert A. Gilchrist, director of the center, explained that new personnel for the center will be recruited from about as self-sufficient within NASA as it is for Mercury. Training will be located to a 40-acre site and procedures transfers to be installed at the Houston complex, and a mission control center, which NASA wants to locate at Houston for both mission termination and mission operations.

• **Engineering support** instruments

tion, computing and data system and data services.

• **Administrative** costs, contracting and procurement and personnel.

Pitzer and the philosophy is not to duplicate existing facilities, but to build new ones only after technology reaches the point where other sites are needed. Existing plantations, for example, will be utilized wherever they are available. Simulations for operations, docking and lunar landing will be constructed, but only after prototypes have been designed at Langley and Ames Research Centers.

Training Ground

Facet characterized by Research and Development Division as a training ground for engineers and scientists who will be assigned to projects. He feels one of his most central tasks is to create a pool of people who recognize problems, and who are able to identify long lead-time items. Within the context of the Manned Spacecraft Center mission, however, R&D is an adjunct. It is totally oriented toward specific objectives. This is shown in eight fields being performed within the division.

• **Spacecraft Research**. This branch has the general responsibility of writing a manned spacecraft design manual. The management of an all-inclusive compilation of existing engineering knowledge, such as structures and loads, living quarters, consumable safety margins and procedures for establishing trade-offs in support of Gemini and Apollo projects, that branch must provide to the spacecraft as a whole to determine how best the system should be modified. This involves detailed analysis of weights, flight dynamics and structural analysis.

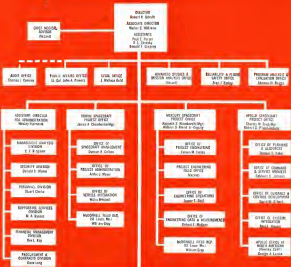
• **Life Support**. The central control of the spacecraft is the life support system and a number of ground-based simulators for advanced research and training are planned by National Aeronautics and Space Administration for exploring the problem of living in space.

Landing Simulators

Working in three dimensions, flight simulators and a number of ground-based simulators for advanced research and training are planned by National Aeronautics and Space Administration for exploring the problem of living in space.

A prototype landing simulator is under construction at Langley Research Center using a tethered capsule. The center facility will generate technology for an operational simulator being built at the Manned Spacecraft Center for pilot training and computerized testing. The third landing simulator, a free-flight system, would be used at the Flight Research Center at Edwards, Calif., to solve the problem, from an altitude of 5,000 ft.

Manned Spacecraft Center



GENERAL ELECTRIC CO., engineers will data from a test of the company's fuel cell, to be incorporated in the Gemini spacecraft for power and drinking water. A cell unit is in the background with a heating element around it. The Gemini system will consist of two systems each with three stacks of cells. A stack contains 51 monolithic cells fueled by hydrogen and oxygen.

and project officer is accommodation, and development manager for personnel. Like the Spacecraft Research Entity, this element has the task of establishing tolerance criteria across a broad front to assure that no artificial physiological restrictions will hamper the program.

• **System Evaluation and Development:** This is the last, relatively, element of the Houston center. Its functions will be to assess existing and define components. At that time, its major task has been the creation of facilities to be used for evaluating. Among facilities under design are large, various chambers, housing eggs and birds instruments.

• **Space Physics:** Clothing house for experiments to be conducted with Gemini and Apollo spacecraft.

In addition, Fagot's Division has a general responsibility to "get better

components for future spacecraft," and the division sponsors advanced technical development work in the general area of product improvement. Preliminary design studies for the future presently emphasize advanced heat shield technology, nuclear and solar power supplies, on-board propulsion systems (improvement, present tests and the orbital crew environment problem).

To perform its functions, the center is obtaining a comprehensive inventory of laboratory and development facilities. Now under construction or in design are a spacecraft research building, structural test laboratory, electrical, electronics and cyber laboratory, materials and mechanical systems laboratory, spacecraft environmental test chamber, assembly facilities, flight simulation centrifuge and thermodynamic test facilities.

Manned Spacecraft Center is estab-

holding extensive communication lines to insure that effective liaison exists with other NASA installations, and also with its principle contractor. Suitable liaison activity exists with Marshall Space Flight Center in the Apollo program, because Marshall is responsible for the Saturn vehicles which will launch the Apollo spacecraft. There are joint panels in 21 operational and mechanical interface areas, and in quality assurance and check-out.

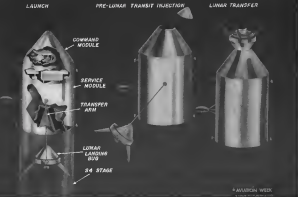
Langley Research Center, which does a considerable amount of general research in manned space flight, has appointed Axel Mellgren as a permanent representative at Houston.



NASA Launch Vehicles

[illegible]

Notes: ^aYields calculated not isolated. ^bYield in C-5 best is calculated. ^cYield is E-1 isomer calculated. ^dTrapped with methanol. ^eArborealolone: 58% (3), General Synthesis/Arborealolone: 60% (3), General Synthesis/Convolv.



LUNAR ORBIT rendezvous method of landing men on the moon may involve this sequence. Transfer bug would be transferred to the command module nose to start service module propulsion could operate for maneuvers enroute and descent for lunar orbit.

Apollo Management Is Focused in Houston

Houston—Fundamental decisions relating to the evolution of the three-man Apollo spacecraft are being made daily in three key locations across the country, with the focal point at the Manned Spacecraft Center here, which has the responsibility for the development of all hardware from the transition selection point through the completion of the manned lunar landing mission.

Overall management of the Apollo system emanates from National Aeronautics and Space Administration Headquarters in Washington. The third key location in the network is Downey, Calif., where North American Aviation is building the spacecraft under technical and quality criteria set up in previous manufacturing history.

Apollo is successful, the first program NASA is conducting under the systems concept, the philosophy aimed at tying in all parts of the Apollo program into a single, integrated effort. Responsibilities for the major system elements are clear-cut, and interface problems are quickly brought to the attention of the designers working—Bellanca, Bellanca, in charge of Manned Space Flight, and Douglas F. Shaw, Bellanca's deputy for systems.

Charles A. Frick, Apollo project manager, is responsible for the day-to-day development of the capsule and its flight mission. The management office here, and his plant office in Downey consist of a mission manager of lunar industry and government technical executives. He has been given a rela-

tively free hand to build the most tailored management system he can see fit, and his office, now totaling 85, will gradually expand to 280 during the next 12 months.

Frick's deputy is Robert O. Pland, who directed the Apollo program through its conceptual stage when the project was an advanced study in the Space Task Group at Langley Field. Frick recently headed the "astride moon" branding all phases of the program conducted away from the Manned Spacecraft Center. Pland's task is management of the NASA activities conducted here which includes the month to monitor command and service module, guidance and control, system integration, flight safety and quality assurance.

In addition, Pland is acting chief of the lunar landing module program office. The lunar lander is a breaking step which will debar the Apollo spacecraft so that it can enter into a lunar orbit, and then further break it to a velocity of about 770 ft. per second for a lunar landing. North American's service module will perform the actual touch-down landing maneuver.

Lunar lander will be a part of the Apollo system of the earth-orbit launch mode is selected for the Apollo mission. If the lunar orbit mode is selected, the lunar landing module will be classed lunar orbit.

Houston Group

Frick's Houston organization is structured this way:

- **Spacecraft modules**, directed by C. C. Johnson, with one lab branch chief monitoring only major subsystems, and others responsible for power, growth, mechanical systems and electrical anomalies, and ground support equipment. Branch chief is astronaut's direct contacts with the project.
- **Planning and resources**, headed by Thomas Burt. This group develops schedules, budgets, hardware and cost control, the last function in analysis of

what is being spent, and when it is being spent. Program Evaluation and Review Technique (PERT) is a critical part of Burt's procedure. David Bower, a member of the astronaut selection staff, is the contract representative in the office.

- **Guidance and control**, David Gilbert, who is the Massachusetts Institute of Technology contact for that system.

- **Systems integration**, headed by Dr. Paul Woychik, whose function is to coordinate checkout, integration of spacecraft and launch vehicle in conjunction with the Marshall Space Flight Center, mission engineering, ground operations support system requirements, and reliability.

General Electric, which will assist NASA with checkout and reliability in the Apollo project, will have more sections in Houston than will work through Dr. Woychik. Frick pointed out that in no case will GE retain over 50% of the contract. The company will track interface integration problems in a still critical of a line contract. In reliability, GE will monitor such problems in new hardware, mission vehicle, and mission time-to-failure, space required and optimum recheck-out systems.

In the operations area, Robert R. Gilbert, senior director, Walter C. Williams, his assistant, director, and C. C. Kraft and Merritt Preston, his operations managers, frequently institute changes to meet operational requirements into technical specifications.

Apollo Design

Design and service characteristics which have been made for Project Apollo include:

- **Command module**, to have a 150-in. dia. with a 150-in. dia. will shape. It will weigh approximately 10,000 lb.
- **Service module**, also to have a 150-in. dia. to match the command module. Launch has not been fixed because the precise amount of propellant has not been established. Weight will be about 20,000 lb.
- **Maneuverability** will be obtained by offsetting the center of gravity 5 to 10 in. from the vertical height lifting rate will be 0.8, and maximum lifting rate will be 1.7. Potential landing gear point at velocity will be an area 500 m either side of the centerline, and 1,000 m diameter. Recovery angle will be 30 deg.
- **Recovery** will be on land. Present plan is for landings to be accomplished by a chute of about 55 ft. parachute, one of which will move a side landing. If the Apollo system is to be used in Germany, the Apollo spacecraft will be altered with this system.

Frick's executive assistant is Thomas Mosley, and R. C. Schold is a contract Apollo manufacturing.

Resident project manager is Downey is George Leslie, whose primary functions are engineering, quality assurance and reliability, and business administration. He is functionally responsible to Johnson in Houston, and is in charge of his operations in the same way Johnson's command and service module division is responsible.

Leslie defined his position as a "manager" in confidence and minimum system reliability. He will have about 10 technical people on his staff—1000 in total among the engineering, design, and quality control design groups.

Talks contacts between NASA and North American on specific problems are supplemented by formal bi-weekly meetings. NASA and NAA have established working groups which are joint staffs in eight specific areas. These working groups may well split up to do so in safety, space problems, as in the case of the major technical problems exist in:

- **Reliability of the subsystems**, particularly in service module and attitude control, guidance, navigation, electrical power supply, environmental control.
- **Development of operational techniques** and display and controls for rendezvous, lunar touchdown and the checkout and countdown for lunar orbit.

North American is in high gear on the Apollo program, and is looking to start 1967 for delivery of hardware and tracking Apollo models.

John Paup, NAA vice president for Apollo, expects his company to acquire orders for 16 to 18 complete modules, to be built in three degrees of complexity. First hardware will be used for impact tests at the Downey site and for several drops. Later models consisting of both command and service modules will be flown in July 68. 2 vehicles on ballistic trajectories to verify design criteria and to qualify the major design criteria.

North American also will build attitude and guidance systems, which will be designed to the command module and these systems will be used to control the mission profile studies.

Miss command module, wooden structure, an order construction in a plant area. North American calls "space village," because the capsule looks like an Indian teepee. Paup explained that helicopters will be used "to find things out, mechanics will be used to keep the system in good shape."

Placement and coloring of instruments, compatibility of electronics, handling and servicing, attitude lighting and optics are among the design problems NASA and NAA will help solve.

Reflecting NASA's demand for qual-

ity assurance, North American is using Apollo flight hardware quality control procedures to build wooden models. This allows the company to train its manufacturing people in advanced quality assurance techniques, and to use the techniques in the final production. Polymers will be used to manufacture a spacecraft with the same restrictions as a conventional aircraft.

Pending decision on whether early or late orbit rendezvous will be selected for the Apollo mission mode does not give North American's work, according to John Fisher of headquarters Apollo office.

Baker said the external configuration of the command module has been fixed (see last) to the point where the company has been able to start work on the design of the post-orbit command module.

He pointed out that nothing in the Apollo design is beyond the existing state of the art, although the fuel cell system to generate power and drinking water—probably gone further in technology. Indeed, he said the major technical problems exist in:

- **Reliability of the subsystems**, particularly in service module and attitude control, guidance, navigation, electrical power supply, environmental control.
- **Development of operational techniques** and display and controls for rendezvous, lunar touchdown and the checkout and countdown for lunar orbit.

Apollo Subcontractors

Houston—Subcontractor estimates for major Apollo (project) system total \$251 million and the prime contract for systems will have a value estimated at \$1 billion.

Representatives are still being contacted with North American Aviation's Space and Information Systems Division for the question with liquid contracts to be let in phases. Few plans will start work through the engineering design, and the second contract will be through delivery of the prototype.

Recent announcements by the Institute of Technology, has received contracts totaling \$40 million for development and production of the Apollo guidance system. The top contractors are:

- **Mississippi State University**, \$60 million for the attitude and control system.
- **Collins Radio**, \$50 million for the communications system.

- **AirResearch**, \$24 million for development and construction of ground system.
- **Manitowoc**, \$124 million for the reaction control system.
- **Avco**, \$117 million for heat shielding.
- **Purdue**, \$18 million for the fuel cell system.



MODULAR structure of the Gemini capsule around the pilot's compartment in this side model.

Gemini to Be Testbed for New Techniques

Houston—Ride of Gemini as the first truly operational U.S. manned space vehicle has been overshadowed by current Mercury flights and the more ambitious Apollo program, but Gemini is expected to become the flexible testbed for new techniques and systems for both scientific and military space flight.

The two-man Gemini will permit long duration flights for assessment of the effects of space environment on humans and equipment, test and demonstrate rendezvous techniques, reentry design shortcomings that have become obvious through the Mercury program, and it will place increased reliance on the astronaut as a pilot and controller.

With an 8,000-lb. Gemini will be a true ground-to-orbit spacecraft rather than a simple adaptation of Mercury. The only solid rocket boosters for the two vehicles, both of which are being built by McDonnell Aircraft Corp., will be external configurations. Even the fundamental design philosophy has been altered.

Rapid Development

Gemini is being designed under the modular concept with major systems to extend outside the pressure vessel, quickly available for replacement or servicing through access doors. Mercury has a barrel-like design, with systems piled one on another inside the pressure vessel.

Gemini was approved as a project only eight months ago, but final design

standards. They will permit a two-day rendezvous mission with a 6,000-lb. payload or a 16-day orbital mission with a 7,500-lb. payload.

The rendezvous configuration will permit slight changes in orbital plane and permit approach to a target vehicle.

The long-duration vehicle will have the facilities for a two-man crew or a pilot and a manager of experimental animals.

Key features of the Gemini entry are to tolerate a 3,500-lb. impact, including an estimated 5,500-lb. impact to McDonnell Aircraft Co. entry into the atmosphere. The McDonnell contract is still under negotiation.

Major problems continue have been solved with:

- Intercontinental Bombers: 500 million for aerial guidance.
- Rocketry: 514.4 million for entry vehicle and a remaining service cost of \$100 million.
- McDonnell-Houston: 35 million for the aerial recovery.
- Const. Corp.'s Alcoa: 56.4 million for the environmental control system.
- General Electric: 55.6 million for the fuel cell system.

The adapter also will house eight power control thrust chambers and six of the 24 attitude control jets. The reentry control system consists of eight 100-lb. thrust units, two of which fire aft or down, two forward, and four in the direction of displacement.

Attitude control jets have a 28-lb. thrust. Sixteen attitude jets are located in the neck of the capsule, a section called the reentry attitude control unit, two are located in the reentry module, and an arc in the adapter structure.

The adapter will become a part of the Gemini apparatus in both rendezvous and long-duration configurations until completion of the mission. At that time, the spacecraft will be oriented to a 24-deg. reentry attitude and the adapter will be jettisoned by a shaped charge heuristics in the reentry module and the adapter.

Reaction control jets for both reentry and controlling attitude will be fueled by isopropyl alcohol. Fuel will be metered by a reentry valve and the adapter will consist of several stages of nitrogen. This configuration will provide a specific impulse of more than 230 sec.

Propellant will be stored in blast demarcated with a metal disk which will be jettisoned automatically after the vehicle is inserted into orbit. Thrust chambers will be fired, and will use aluminum-coated nozzles. Scheduled valve controls will eliminate hold and reset extremely short thrust pulses—less than 15 to 20 milliseconds.

Re-entry Vehicle

The reentry vehicle, with a base diameter of 90 in., houses the pressure vessel, command compartment and the electronics and major systems, which are located between the pressure vessel and

the spacecraft. Primary spacecraft power system will be supplied by a system of six module fuel cells, based on its zero-headroom configuration to produce both electricity and driving water through chemical reaction of hydrogen and oxygen. Two separate waste water battery supplies will be provided, one for drinking and safety and the other for waste and propulsion, and the other as a backup and for use during re-entry.

The fuel cell system will deliver a gross power level of 1,000-1,200 watts against an average predicted requirement of 600 watts.

The only major system located within the Gemini pressure vessel will be environmental control, which will handle pure oxygen and maintain a 5.1 psi cabin environment. This system will vent oxygen and will have the most major human air in the Mercury system. Carbon dioxide will be controlled by chemical absorption and not temperature will be controlled by oxygen changing to water through a heat exchanger. Humidity is controlled by water removal downstream from the heat exchanger.

Oxygen for use in orbit and oxygen for use in reentry will come from two independent systems, the orbital system located in the adapter and the reentry system in the reentry module.

Pressure suits of both astronauts will be connected in parallel in a single closed loop system, which means the pilots must fly in a depressurized environment.

The reentry module will have large access doors for servicing and replacing equipment without the need to jettison the entire capsule. This will allow use of the major problems found in Mercury. When a system fails to check out, it will be replaced on the pad. On several occasions, the Mercury capsule had to be jettisoned from the launch vehicle and generally disassembled to remove a system found faulty during checkout.

Gemini pilot seats will be on rails, but astronauts will have radically modified cushion from the backrest up. Seats can be reclined by either crew seat. Each will have a D-ring extension which will open both in a single operation.

Irrevocably forward of the reentry module in the reentry section control system structure, and forward of that section is the parabolic storage compartment and maneuvering system.

Interpretation of maneuvering commands, a display center of gravity and the parabolic system are the main features which continue to make Gemini an operational spacecraft, capable of positive maneuvering in orbit, during reentry and after reentry.

Harvey Dotts, Gemini structure chief explained that the center of

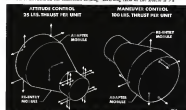


DRAWING shows Gemini-Titan 2 during boost. Abort escape will be accomplished with system tests.

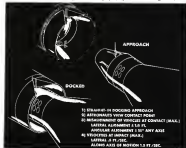
gravity is offset 3 in. from the spacecraft centerline, and by reentering the atmosphere with a 16 deg. lift, a lift/drag ratio of 0.25 can be obtained. This results in a controlled roll, which allows the spacecraft to be landed in the generally desired direction, with a landing "footprint" 900 sq. ft. and 200 sq. ft. wide at the beginning of reentry. Landing angle is to be reduced during reentry will keep the peak heat pulses, and this necessitates a space that different structural heat protection sheets than is used in Mercury. The heat shield will be a combination of glass fiber and phenolic resin, but it will not be uniform in thickness. Hot spots and corners will be built up, and similar ablative materials will be in-



GEMINI PARAGLIDER for controlled landing. Lifting role of the eases a 52



MANEUVER AND ATTITUDE control control channels in 35- and 160-lb. Gemini jet (left). First controls Gemini Agena B develop by firing rocket jets into gnomes (below).



stalled around the reaction control system module at the spacecraft tank, which is subjected to intense heating loads during reentry.

The neck section of the Mercury capsule is protected with boron-plated plates, but they are too heavy for the Gemini system.

The paraglider is designed to make possible a point landing anywhere within the footprint and to compensate for errors introduced during re-entry. The paraglider, which weighs 510 lb., is stowed in a 10-in. x 10-in. container. Deployment will begin at an altitude of 10,000 ft., and it is completed at 40,000 ft. at the start of the glide maneuver.

When the glider is fully deployed, Gemini has a 5.2 ft/sec. velocity, and the capability to maneuver 25 ft/sec. downwind, or 15 ft/sec. upwind.

The capsule is flown into a landing by the pilot, who uses a hand controller to adjust gaseous-actuator wheels, two in order to vary pitch and two for roll. A fifth cable is freed. The point landing system is accomplished in four steps.

1. **Glides**, from 40,000 ft. to 1900 ft. altitude at an angle of 17.5 deg. downward velocity of 68 ft/sec. and sink rate of 20.4 ft/sec.

2. **Pre-flare**, from 1900 ft. to 45 ft., actually a dive to increase forward velocity to 96 ft/sec. and sink rate to 35 ft/sec. Speed angle is dropped to -15 deg.

3. **Flare**, from 45 ft. to impact, with steep angle increase to -3 deg. and forward velocity slowing to 46 ft/sec.

4. **Touchdown**, which is made at a maximum vertical velocity of 5 ft/sec. and a horizontal velocity of 60 ft/sec. Approximate forward distance has been computed to be 200 ft.

Navigation of whether cold jets will be used to speed the cable retraction, and landing study will be made of a heat-treated steel.

Origins of Concepts

The Gemini concept began in April 1951, with James Chamberlain at a release for redesigning Mercury to make it easier to perform as Mercury mission for use in the Gemini program. Gemini project managers believed that the modular design philosophy, the paraglider and reaction jets could quickly be incorporated into the Mercury design. Reaction jets will replace the short-term need in the Mercury system. Although the former concept is probably the most reliable about parachutes, the weight makes it incompatible with the Gemini's Agena Titan 2 launch vehicle capability, and there is no off-the-shelf rocket propellant available for a Gemini escape system. The test also reveals, which the tower would not.

Chamberlain's initial ideas have matured into the present Gemini system. Although the first Gemini mission will terminate in parachute recovery, it is the only planned mission planned in the 12-flight program. An extreme parachute deployment program will begin a climb 60 days. In the first phase, 20 unmaneuvered parachutes Gemini will be dropped from Lockheed C-119 aircraft to make sub-controlled landings. Phase 2 calls for North American Aviation test pilots to demonstrate the system in C-119 drops, and the third phase is for NASA astronauts to make controlled landings after drops.

NASA is considering using the spent Titan 2 launch vehicle, second stage as the target in early deployment flights of Pad 14 at the Atlantic Missile Range is not free in time for these flights. Pad 14 is the only pad available for Project Mercury launches, and 15 orbit Mercury flights. When these missions are completed, it will be adapted to accommodate Atlas Agena B studies for the Gemini program.

Team first indicated that an escape system using with subject the pilot to a load of 12.5 g., not as severe as existing from high performance aircraft. Mercury dynamic pressure for the Titan 2 Gemini combination will be 300 lb./sq. ft. compared with 952 lb./sq. ft. for the Agena-Mercury combination.

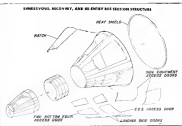
Gemini's Titan Booster

Titan 2 launch vehicle will boost the Gemini spacecraft into orbit at a constant angle of the Titan 2 nozzle, and component parts along the trajectory located around the Agena B adapter. This mission provides angles, angles and stage sizes for reentry, parachute, and stage sizes for the Agena-Mercury combination.

Many differences between the Agena and the Gemini launch vehicle are the addition of a multistage rocket system (MEG) and some supporting systems, and the switch to a radio guidance system instead of an aerial guidance system. MEG system will be located at control points to assist track and thrust characteristics and 1-in.

Attempts to secure reliability in the Gemini booster have been authorized by NASA in two main ways—increasing redundancy into one of the critical sections, and use of a critical component program which requires more component testing for NASA and its vendors.

Weighting Titan 2, with a contract of 30 ft., has a booster thrust of 450,000 lb. and a second stage thrust of 100,000 lb. It uses hexagonal, double-propellant first stage 748 in. x 140 in. and the second stage is 405 in. high. The Gemini spacecraft is 105 in. high, gives the launch configuration a length of 307 ft.



MAJOR STRUCTURAL components of the Gemini spacecraft include the modular design of the capsule. This 510-lb. paraglider will be stowed in the capsule at the start. Immediately after the module which houses main Reaction Control System (RCS). Down Gemini access to equipment and to environmental system. Unlike the Mercury capsule, Gemini will have five components made the previous craft.

In a typical reentry mission, the Agena B target will be launched first into a 110-m. circular orbit. The Gemini spacecraft then will be launched in the same orbital plane into a slightly elliptical orbit, ranging from 57,140 to 58,000 ft. Because of the difference in velocity, Gemini will approach the target at an angle of 15 deg. per revolution, and this process can be repeated by changing the orbital path of Agena to slow it down.

When the two vehicles are 250 ft. apart, the reentry mission will be initiated. The Gemini spacecraft will be the transponder located around the Agena B adapter. This mission provides angles, angles and stage sizes for reentry, parachute, and stage sizes for the Agena-Mercury combination.

Range Decreased

When the range has decreased to 50 ft., the technique switches to a second, more basic, an electronic receiver in Gemini and a light-emitting diode in the target. The new actually fire Gemini into the Agena B adapter system, using its radio that in line up with a ground in the subject.

The present concept is to use a straight-in docking approach. This calls for precise path control, with only one foot lateral and 10 deg. angular misalignment.

Lateral docking angle is estimated at 0.1 ft. and 1.5 ft. along the axis of motion.

The Agena B adapter system will have three hand points, or seats. When Gemini connects with the target, the adapter will be cooled solely in the

target to form a single rigid vehicle. Disconnect will be made by steering the Agena B.

The pilot will have a four-wheel and two automatic struts, which will include foot pedals recommended by the Project Mercury astronauts to control the Agena. Direct pilot controls will be in-line, single push for line adjustment, proportional rate control, and rate control for attitude hold.

Automatic Systems

Automatic system will be provided in attitude hold and is what will be called the orbit mode. The latter system may extend to pick up the horizon and a self-aligning control will be provided, allowing the capsule to stay on target though the spacecraft will drift in time.

Special Gemini Tests

Proton-Experiment which would permit one of the two capsules to leave the spacecraft while it is in orbit is being considered by Project Gemini. A rocketing device is being developed that will hold the capsule up as an object, as called in the report by an orbital mode, would be able to operate outside the capsule.

Environmental tests would be provided either through the simulator or by means of a microfilm model or backup.

Another advanced experiment under consideration is the use of the spacecraft to dock with an unpowered propulsion stage, better than the Agena B.

Mercury Provides Data for Apollo, Gemini

Hampton, Va.—Project Mercury, conceived under tremendous pressure four years ago in the face of Soviet space successes, has evolved into a valuable building block in the U.S. manned space flight program, and before it is completed, it will provide much of the fundamental knowledge for the Apollo manned lunar landing mission.

Murphy had a single objective at the outset—to verify the ability of man to function in the space environment. This objective was met last Feb. 20 with the three-orbit flight of Marine Lt. Col. John H. Glenn, Jr. It was confirmed last May 24 when Navy Lt. Cdr. Scott Carpenter flew a second three-orbit mission.

Because the pressure to advance has been on Mexican since its inception, the three-day session will grow to four-day sessions about six months from now.

There has been a tendency to identify Project Mercury with the capsule and its pilots, but they are only aspects of what has become an extensive program geared for the Gemini and Apollo programs.

Full Mercury version consists of a government-industry team that has given the U.S. the means to design, engineer and manufacture a manned space vehicle, which was qualified and flown by man 17 months after the prime contract was let.

The system has provided a world wide tracking network with the capability to handle data on a real-time basis. It has given controllers the opportunity to devise satellite flight and recovery procedures.

The Mercury system evolved during a time when U.S. international prestige was flourishing from diplomatic ach-

reflect heat from which is processed in extending the Mercury profile to six nights and then to a full day of orbital light.

There is a plan under consideration to fly two six-orbit missions and two or three one-day missions. This plan will carry the standard space flight program forward until the fall of 1963. At that time, launch facilities enter the schedule on a more urgent basis.

Pod 14 at the Atlantic Missile Range at the ash. Messing's launch complex. It is also the facility from which the Agos B stage will be launched for the Gamma underwater mission. If Gamma missions are to start in early 1964, Pod 14 must be available early next fall for modifications to handle the Atlas Agos B launch vehicle.

Primary purpose of mission is to provide baseline astronomical data on the effects of prolonged weightlessness. In orbit, a maximum of 100 days is required for the launch of the vehicle. NASA has established a two-week time-frame for the launch of the vehicle. The launch of the vehicle is scheduled for 1990.

and the expanded Mercury program now conceived will not delay the schedule.

NASA is satisfied from the Glenn and Carpenter flights that a propeller-driven, experimental test pilot will not be hampered by extended weightless flight. But the agency wants to verify that, in some of the more strenuous

In Soviet May Glushko Ties after the orbits of his 17 orbit missions. Although a second assignment was a slightly recent consideration in the Moscow program, it can provide the opportunity for detailed extended mission during more than 500 hrs of flight without significant capsule modification.

An on-line plant calls for an increase of positive plant attitude control during a significant portion of the flight. The pilot will exert control during the first two weeks while precise orbital elements are being calculated. At the start of the third week, a decision will be made whether to continue the flight for six weeks, or to end it after four. If the decision is to continue, the antimatter section control system will be made inoperative to conserve fuel and many of the power-consuming components will be switched off to save battery power.

Capsule will then drift as far as altitude is concerned for the third fourth and part of the fifth orbits. About midway through the fifth orbit, systems will be configured for the final orbit and reentry.

Recovery Area

Recovery area after six orbits will be near Midway Island in the Pacific Ocean. The tracking ship *Rose Knot*, now being modified to give it command capability, will be stationed near the Philippines. It served as the Project Mexico Atlantic Ocean Ship through the Cuban flight.

Modifications in the oxidant capsule configuration can be utilized in the next-day capsule, according to Charles McGuire of NASA's Mission office in Washington. He said that as a result of a ground weight reduction program and removal of some redundant com-

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Mercury Contracts

Hampton V₂-Subject Measures will have a total cost slightly in excess of \$400 million through its four-year funding lifetime which will end during Fiscal 1993.

McDonnell Aircraft Corp., prime capsule contractor, has received orders for 20 capsules, two preflight trainers, six environmental trainers and ground support equipment. This figure includes \$12 million in module line capsules for on-orbit training.

Other major capital construction set Colfax Radio telecommunications, A. Research, pharmaceutical refines, Calspan, and Telling Laboratory, heat ducts, Nurling Vending, recovery, Monopoly-Honeywell navigation, Bell Aerospace, nation controls, and Lockheed Bombardier, engine rocket.

parents, the one-day capsule will weigh nearly 100 lb less than the nesting Mexican capsule, which has a lift-off weight of 4,265 lb.

Among components to be screened are the T-4B gyroscope and the complete rate distribution and control system (RDCS). NASA also is considering removal of the backup telemetry system.

ASCS, one of the four attitude control systems in the Marscap, capsule, and surface Glenn and Cassini units (1). The Marscap capsule will retain the automatic stabilization and control system (ASCS) for basic and manual proportional control. The latter two systems are manual, providing control when the pilot needs a manual mode. The automatic system reacts to signals from a horizon sensor unit.

Considerable effort is to be expended for the on-line services will be required for the environmental control system, water for cabin and wet cooling, and battery power.

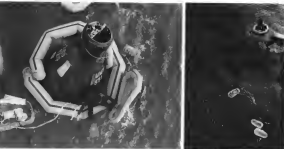
The worded version has essentially the same objectives as the wordless version in that it will extend man's weightless flight experience and provide an opportunity to assess the effects of gliding after prolonged zero gravity flight.

Glen and Carpenter contributed significantly to the decision to advance Mercury beyond three orbits, since their performances resulted in consideration of the pilot as an active part of the capsule system. After Glen's flight Robert R. Gilruth, director of the Manned Spacecraft Center, said, "The presence of the human crew should lead to design criteria that spacecraft must resemble in manned aircraft form to facilitate entry."

"Since man has now demonstrated his ability to operate in the space environment," Gherzi said, "vehicle design for increased space flight can now consider full utilization of human crew capabilities. This utilization of crew should lead to increased reliability in terms of better flight safety and mission success."

Seward Prisoners

Operational shortcomings in Mercury flights, with some few exceptions, have been traced to techniques other than to any fundamental fault in a system. With the experience of 10 ballistic and orbital flights, the Mercury system has proven to be a sound one. But its most important significance lies in the fact that, as the first U.S. step in manned space exploration, it has proved to be sound and safe.



AURORA 7 light capsule of Lt. Col. Scott Carpenter is shown during retrieval operations following its flight last May 26. Flotation collar was inflated around landing capsule by umbilical derrick, one of whom is visible on collar at left.



MERCURY ATLAS-3 configuration used
General Dynamics/Astronautics After 307D.

Marshall Directing Vehicle Development

NASA's largest center uses flexible tools to manage in-house and contractor production of large boosters.

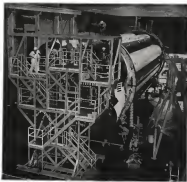
Princeton, N.J.—Launch vehicles are the business of the George C. Marshall Space Flight Center and all work here—from experiments with liquid hydrogens to the study of various reentry techniques—eventually is applied to moving a payload from a point on earth to a point in space.

Under the direction of Dr. Wernher von Braun, former director of development for the Army Ballistic Missile Agency and rocket scientist at Peenemünde during World War II, the center now is assigned to

- Development and flight-testing of the Saturn C-1 launch vehicle
- Detailed engineering design of the Apollo/Saturn, or C-5
- Detailed preliminary design of the Nova vehicle
- Development of reentry systems, including the Transcatal and Earthrise modes
- Procurement and adaptation of Test Article, Afterburner and Afterburner Launch Vehicle
- Studies of future requirements, ranging from post-Nova launch vehicles to the standards of propellants on the moon

Divisions, Project Offices

Marshall is organized into nine support divisions—administrative, astronautics, transportation, manufacturing, engineering, propulsion and vehicle engineering.



WORKMEN assemble Earth Saturn C-1 flight test vehicle at Marshall center.

new. Large will return these engineers to their divisions, where they will be reassigned to other projects.

The flexible arrangement allows project directors to give the use of their offices to the best-qualified crafts of a project's life cycle and encourages manpower utilization. It also tends to have two main engineers personally involved in, or oriented to, one project and seeks for a minimum of major changes and reassignment in one project phases and a new one phase in

Management Tools

Marshall uses three basic tools to manage its programs—working groups, coordination panels and the technical board meeting.

Working groups are in-house units which supplement the project office in the development of a system—whether hardware or facilities, study-by one confirming the best technical personnel available from the support divisions in specific problems or critical areas in the system. Each group is led by a Marshall branch chief or division director and includes representatives from other NASA centers, Department of Defense and the contractor.

All efforts are scheduled in accordance with the group chairman is the office for which the group is working. Sessions or recommendations are presented to the project office for approval. Decisions of the working group are not binding upon the project office, but may, the group is known to not the office in a particular sphere of competence, its suggestions are usually are followed.

Robert F. Lockhart, branch manager of the C-1 project within Saturn Systems, has eight working groups covering various areas for his office. These groups track the support data from the divisions in the project office.

• **Vehicle Mechanical Design Integration**, under Hans Feltner, whose title for integration is chief of the vehicle systems integration branch in the Propulsion and Vehicle Engineering Division.

• **Vehicle Dynamics and Control**, under Dr. Ernst D. Gostler, director of the Aerodynamics Division.

• **Vehicle Instrumentation**, under Otto A. Holsing, chief of the instrumentation development branch in the Astronautics Division.

• **Electrical Systems Design Integration**, under Hans Feltner, chief of the electrical systems integration branch in the Astronautics Division.

• **Vehicle Assembly**, under Hans Meiss, director of the Central Planning Office.

• **System Checkout and Pre-Flight Test**

Marshall Space Flight Center

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Assisted by the Director
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AERO/SPACE OPERATIONS: From the water surface to the bottom of the sea, from the study of space vehicles to space systems... new propulsion methods, the development of space vehicles... the GM-100 is dedicated to the study of the sea.



LAND OPERATIONS: The scientific knowledge is applied in GM-100's search for more effective systems (working in the surface environment). Research into land mechanics, structural analysis, and electronics is resulting in new systems for land vehicles and land and planetary exploration.

BIOLOGICAL STUDIES: "To extend our knowledge and capabilities in the biological sciences and technology, expanding our understanding of life in relation to the sea and the environment through various research and exploratory development programs." This is the goal of the GM-100, research.



GENERAL MOTORS DEFENSE RESEARCH LABORATORIES, SANTA BARBARA, CALIF.

ing, under Peter Goss, director of the Quality Assurance Division.

• **Launch Operations:** under Dr. Karl Dehn, director of the new Launch Operations Center at AMR.

• **Flight Evaluation:** under Dr. F. Speer, chief of the flight evaluation branch in the Aeroballistics Division.

C-1 also has eight working groups, covering the same areas as C-1 groups and whose groups are appointed as needed to solve problems falling outside the area of the regular working groups. Working groups are not management organizations, because each the chairman has authority to make decisions and to meet some responsibility for the group's actions. Another program has four working groups.

The Marshall Spaceflight Center (MSC) at Huntsville, Ala., also has working groups in developing the Apollo capsule. They correspond line monthly to the Saturn groups at Huntsville. Von Braun and his staff had signed MSC, which is now still the Space Task Group of Langley, Shivers, Hampton, Va., to adopt a management structure similar to Marshall's also it transferred to Texas reflect that year and MSC agreed.

Working groups of the two centers meet in coordination panels, which are patterned after the joint assets formed

by the centers for the Marcan-Saturn design program. These panels cover the same areas as the working groups to insure that development of launchers and spacecraft proceed in lockstep. As far as possible, panel members are drawn from the corresponding working groups of Marshall and MSC. Panel membership usually does not exceed 12.

Dr. Jonathan P. Koester supervises Huntsville panel arrangements, but has no oversight in Dr. Paul Wozniak.

Panel members contributed are launch operations, mechanical design integration, electrical systems integration, structural requirements and construction, flight mechanics, dynamics and control and quality assurance and checkout. Additional panels are being considered for flight evaluation and training. The two working groups at Marshall and MSC, respectively from other NASA centers, DOD and industry contractors are invited to join panel sessions.

Bell, of the panel's work is done through informal meetings and close work between the working groups here and at Huntsville, the panel meetings frequently serve to work out details of agreements already reached, as well as to solve problems which affect the related.

Results of panel meetings are forwarded through Koester and Wozniak to the Saturn program and Apollo program offices. From there, the panel reports go through two lines and Robert R. Gentry, MSC director, to Richard Haines, director of NASA's Office of Manned Space Flight and its Management Council.

Designations that cannot be resolved within a panel are referred to a panel. Huntsville's Houston Research Board, composed of the Texas Research Board for Research and Development, Eberhard J. von Braun, Director General Launch and four division directors from Marshall, Gentry has Associate Director Walter W. Wozniak, Apollo Program Director Charles Fick and four other directors from MSC. So far, the board has yet to be called upon to resolve a panel dispute.

Marshall intends to keep its 16-man manufacturing operations, built up during its Army Ordnance days, and will continue to assemble the initial units of the new stage before turning it over to contractors for production.

Von Braun details intentions of this capability on two grounds.

• **Manufacturing competence:** is asserted at a level which permits Marshall to make administrative judgments on the contractor's production. By building one or several small units, Marshall feels it is in a better position to recognize the contractor's work and to solve problems that the contractor might encounter. Marshall is building 11 Saturn



REACTION LIGHT 104 (RL-1) vehicle panel will be mounted from Huntsville.

C-1 development vehicles, and will build at least one Saturn C-1 prototype.

• **Training and development of young Marshall engineers:** as they can effectively discharge, this managerial responsibility. It also is an attraction for new recruits, qualified engineers who find the prospects of working on a hardware program more interesting than drafting contract papers at a desk, and who might otherwise go to industry.

Von Braun and his associates also are anxious to see that the experience gained in one program is applied to similar projects. For example, Marshall would like to see Douglas Aircraft Co. and Rockwell International of North America (Aviation, Inc., space and on gas turbine aspects) of the hydrogen-fueled S-4 stage, from some of the problems encountered by General Dynamics/Astronautics and Pratt & Whitney Division of United Aircraft Corp. in the development of the Centaur upper stage. Wozniak wants to address this cross-fertilization. Marshall feels it is through its working groups.



FACING THE FOURTH DIMENSION IN PROPULSION DEVELOPMENT

Whether the solvent has a "bottle shape," or any shape at all, is a matter of interesting conjecture. The matter of space travel, however, is the subject of intense experimentation. A nuclear/thermonuclear propulsion system, currently being studied at Lockheed Missiles & Space Company, might well become the power source for space vehicles.

Its design incorporates a nuclear reactor only one foot in diameter, generating heat at a temperature of 1800°K. This is transmitted to banks of thermionic generators, converting the heat directly into electrical energy for the ion beam motor which uses caesium vapor as a fuel. The entire system is designed without any moving parts, eliminating the possibility of failure.

Lockheed's investigation of propulsion covers a number of potential systems. They include, plasma, rocket, nuclear, unique designs in chemical systems involving high-energy solid and liquid propellants, combined solid-liquid chemical systems. The fundamentals of aerodynamic hydrodynamics, as they might eventually apply to propulsion systems, are also being examined. Just as thoroughly, Lockheed probes all missile and space disciplines in depth. The extensive facilities of the research and development laboratories—together with the opportunity of working with men who are acknowledged leaders in their fields—make a decision with Lockheed truly rewarding and satisfying.

Lockheed Missiles and Space Company is Sunnyvale and Palo Alto, on the beautiful San Francisco Peninsula, is an exciting and challenging place to work. For further information, write Research and Development Staff, Department M 24J, 359 North Wolfe Avenue, Sunnyvale, California. An Equal Opportunity Employer.

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example to the subject at the top of the Apollo capsule. The pilot would return to the Apollo vehicle through the airlock, the bag would be attached and the engine in the service module started for the flight back to earth. • Self-decking, in which the bag would fly alongside the Apollo and a line would be thrown from one to the other. The pilot then would leave the lunar descent vehicle and, using the line, pull himself back to the mother craft.

Advantages of the lunar-orbit mode of rendezvous is a significant saving in weight—total spacecraft weight, including the bag and the propulsion module, would run between 52,000 lb. and 73,000 lb. in growth time.

Weight savings come in several areas. The bag would not have to carry the heavy Apollo land shield, needed for earth reentry, down to the moon and then lift it off again. This decreases weight of a considerable lunar propulsion system.

The mother craft's propulsion system would have a thrust capacity of 6,000 mph, with which to begin the return flight to earth, and therefore would require less weight for placing the Apollo spacecraft on the proper return trajectory.

Lunar Descent Vehicle

Marshall has suggested to the Manned Spacecraft Center that consideration be given to a lunar descent vehicle almost identical to the Apollo spacecraft, but lacking a land shield. The bag lunar descent vehicle would be abandoned on the moon after the landing had been achieved and the crew would return to earth in a small, self-contained re-entry capsule.

This concept was based on a liquid oxygen-liquid hydrogen propulsion system for earth-orbit flight, and for this very reason, Houston did not find the idea appealing. Manned Spacecraft Center wants immediate, different response from the service module engine, because they serve a dual function: lunar descent and short escape. This requirement is not compatible with a liquid oxygen-liquid hydrogen and so Houston favored proven, earth-orbitable hypergolic propellants.

Lunar-orbit rendezvous has the disadvantage of appearing in a remote and inaccessible region, where little man-made can be rendered in the event of trouble.

In earth-orbit rendezvous, by way of contrast, the entire vehicle could be checked out prior to commitment to flight and, if difficulties appear, the crew could either return to earth or a support crew in another Apollo capsule could be launched into orbit to provide aid.

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Marshall Supervises Booster Development

Marshall develops or buys launch vehicles ranging in size from Thor-Agena to Saturns and Novas.

Huntsville, Ala.—Marshall Space Flight Center is responsible for the support of most National Aeronautics and Space Administration payloads into space. It develops or buys a pool of launch vehicles ranging from light vehicles such as Thor-Agena to giant space trucks such as Saturn and Nova to fulfill this mission.

Cross-section of Marshall's work today shows the major emphasis being given to the development of the two Saturn-C-1 and C-2—and the Centaur upper stage, Nova, the super booster, and the nuclear-powered R-1 stage, still are in the early design phase. Purchase and modification of already developed vehicles such as Thor-Agena and Atlas-Agena, is a continuing task.

C-1, which has been flight-tested twice to date, is the early model Saturn and will consist of an S-1 booster and S-4 second stage. Advanced Saturn, called the C-2, will have an S-1C first stage, S-2 second stage and S-4B third stage. An intermediate vehicle, the C-12, now is under consideration (see p. 104). It would consist of an S-1 booster and S-4B second stage.

Engines for these stages also are being developed under Marshall's supervision. They are:
• Liquid oxygen-liquid hydrogen burning RL-10A, built by Pratt & Whitney, and J-2, built by Rocketdyne. RL-10A, the first liquid hydrogen engine developed in the U.S., generates 15,000 lb thrust and will be used on the Centaur, S-4 and S-5 stages. J-2 is rated at 200,000 lb thrust and is scheduled for the S-2, S-4B and S-1C stage. It is to be used in the Boeing Co. under a five-year, \$240 million contract and will be the first step of the three-stage Saturn C-5 vehicle. (For other calls for Boeing to deliver 7.5-ft-dia boosters, plus several ground test units, and probably will be awarded to design Boeing the role of C-5 vehicle manager.) Additional S-1C boosters undoubtedly will be ordered for the post 1966 period, but Boeing has no guarantee that it will receive the follow-on contract.

The S-1C, which Boeing will build at the NASA-owned plant in Michoud, La., will stand about 140 ft tall and have a 33 ft diameter. Construction will be of the long-run and stringer variety, with the horizontal ribs protruding into the tanks to act as structural baffles. Unlike six-ft-dia S-1 boosters, the S-1C will have two

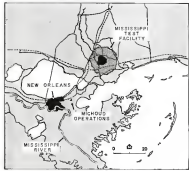
nozzles and technicians under George H. Brown, working alongside Marlene W. Ulrich, chief of the S-1C stage office within the C-5 project office at MSFC, and his Marshall personnel on detailed engineering design. This work is now completion.

This month Marshall will begin building a 40- to 45-ft tall mockup of the booster's boattail that can be checked against design work for interference among different lines and piping around base of boattail.

Using blueprints of the flight design and its own in-house manufacturing capability Marshall will build a non-flammable S-1C at Huntsville. It will be used in a static test firing unit and also provide Marshall with the experience of actually building an S-1C. It is expected to be as useful as the SAT static test model of the S-1 stage which has been fired twice since April, 1964 for a total of 1,501 sec.

By using static loading and simulating some nonsteady-state stress in stage separation jettison and perhaps four Saturn ground effect tests to build the static test model as to size weights before Boeing rolls out its first booster from Michoud in 1965 at rate 1964.

The first flammable S-1C also will be a non-flammable booster. It will be used as a dynamic test model to determine



SATURN LAUNCH vehicles for manned lunar missions will be assembled at Michoud, La., near New Orleans and state border of Mississippi.

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Future Projects Office Pushes Nova

Huntsville, Ala.—Conferences of the Nova launch vehicle from a potential study vehicle to an actual hardware program is a decision of U.S. relations to follow up the mutual home launch project with a broad-based space exploration program.

Nova, now in early design preliminary design phase, development with hardware contracts expected by the end of the year, will have a payload capability of about 280 tons to earth orbit and 80 to 100 tons to escape velocity, approximately twice that of the Saturn C-X. NASA and Marshall Space Flight Center plan to use Nova's single-stage vehicle after the first several assumed lower loadings to load materials and supplies to the moon in a low thrust. Plans also are being made to make maximum use of Nova's abilities in conventional rocketry operations.

First stage of Nova, designated N-1, will be about 115 ft. tall and 19 ft. in diameter. It will be powered by eight Randolph P-1 engines, for a total stage thrust of 12 million lb. Second stage, N-2, also will be about 115 ft. tall, but will have a 40-ft dia. The N-2 will be powered by four S-1C engines, the new liquid oxygen liquid hydrogen 12 million lb. thrust jet engine to be developed by Aerojet-General Corp. Stage thrust of the N-2 will be 4½ million lb. Third stage, N-3, will be 32 ft. tall and 22 ft. in diameter and will be driven by a single 12 engine of 200,000 lb. thrust.

All of the work done to date on Nova has been accomplished by NASA's Future Projects Office, now in home working groups and contractors.

Future Projects, under Director Thomas Koelle, primarily is responsible for the development and evaluation of concepts leading to advanced systems and future launch vehicles—a non-rocketing space exploration, and related launch facilities to a space launcher, tentatively labeled Orion, with a 1,000-ton payload capability.

The office studies, also, whether guaranteed within MSFC or by some outside agency, through the phases of feasibility and preliminary design down to the point of using the design office. It handles the design office, through the Future Projects personnel who have been chosen to the concept phase of the project. It is the office's job to establish a project office when the study becomes an approved project. From 1. Williams, deputy director of Future Projects, has been directing the Nova studies in several ways, new and as expected to become design of the Nova program itself.

But for every MSFC in house study, there are four contracted efforts with industry. During Fiscal 1963, Future Projects expects to award between 20 and 25 study contracts under a list of about 40 identified areas of interest, ranging from vehicle subsystems (such as a design model for electronic systems of sub-orbital launch vehicles) through launch launch vehicles (such as the Orion) to launch base concepts (such as a shelter for the first Apollo crew).

Funds to be spent this year by Future Projects probably will be between \$100 million. Only about 50% of this money will

be spent for hardware and that for experimental verification of a particular idea or technique.

Studies are an essential element of the work of the project office and support divisions and are centrally located by the Research Projects Office. Research Projects Office, long active in projects and divisions are added at the beginning of each calendar year to identify the times they will require resources—on as applied, not base, nature. On a standard basis, an agency develops the work he would like to have done, estimates the cost and suggests one or more contractors capable of doing the study.

This research request is entered by the initiator's immediate agency and then passed up to the project director division chief. If the request involves this screening, it is then forwarded to Research Projects, which makes initial review, comparing it with known research efforts going on in other NASA centers or government agencies. Research Projects then either approves the request or returns it to the initiator's office with appropriate comments or suggestions.

All MSFC launch requests are included in a book with a total dollar figure and then forwarded to NASA headquarters for inclusion in the NASA budget request for the next fiscal year. Whenever money Congress sends to NASA is returned to Marshall and Research Projects agencies funds to do many requests as possible, using priority points awarded the requests.

Research Projects also has a competition field and on several levels, based on standard NASA, permanent policies. Ordinarily, a request is responsible for the technical management of a study contract based on its request.

This year, Research Projects asked for about \$20 million for 500 research requests. Last year, the division asked the about the same amount of money but received only \$10 million in the NASA authorization. It is felt that the pattern will repeat itself this year.

Chief of the Plasma and Atmospheric Branch in Research Projects Division, Dr. Charles A. Lundquist, says his unit, Project Highways—a study of the ionosphere through its effects on a large quantity of water deposited in it.

On the night of January 24-25 last April, the 91 tons of water stored in the January 24-25 and 24-25 report stage in liquid water exploded, which was an explosion of an explosion of the exploded water to see how quickly a patch of the ionosphere broke up after disruption, what the wind characteristics and data were at that altitude and the effect of the water which quickly burst to see on the region's radio activity. Data derived from this experiment still is being processed and analyzed.

Research Projects plans to repeat Highways on another Saturn flight, probably S-4, which is scheduled to be the first this year. Confirmation now is being given to the addition of chemicals in the water so as to reflect changes in the study's ionosphere levels between 100 and 150 mi. altitude.

launching materials and vibration modes. It also will be a dry run for Research's production line and, according to Marshall engineers, a test of the company's manufacturing and quality control process.

S-1C will use five F-1 engines for first stage thrust of 7.5 million lb. Three parallel engines will be located 40 deg apart around the circumference of the base. The 11th, at the center, will be axially mounted.

S-1C will have four line around its base, like the Block-2 S-4 stage, for

structural stability. Short, unalloyed during between the first will have liquid hydrogen tanks from the upper engine. To provide the primary of liquid hydrogen fuel, the tanks will be located on the side of the launch vehicle and perhaps mixing explosively with the first formed around LOX tanks, the hydrogen will be passed down along the center of the S-1C and joints at an angle away from the S-1C's base.

Chrysler Corp. won a \$300 million contract last November from MSFC to build 10 S-1 stages at the Michoud

plant. Chrysler also is expected to be doing systems manager for C-4 launch vehicle, at Boeing near Ft. C. S.

S-1 consists of a central 10-in. dia tank containing liquid oxygen and eight outer tanks, each 70-in. in diameter, alternately holding LOX and RP-1. The five liquid oxygen tanks are pressurized by gaseous oxygen and the fuel tanks by high-pressure nitrogen. All tanks are interconnected so that equal amounts of fuel and oxidant are consumed if one engine fails.

Marshall is building the first eight



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Rift System to Be Mated on Launch Stand

Huntsville, Ala.—Analysis and design of the Rift (reactor light test) system will be started for the first time on a launch stand—and not on a production line as is usual—because these two steps elements of the first U.S. nuclear-powered stage follow physically separate and distinct development programs.

Marshall is responsible for all parts of the Rift stage except the engine. Lockheed Missiles and Space Co. holds a first-phase \$6.3 million contract from NASA for design of Rift and, next May, will begin fabrication, development and testing of Rift vehicles under what is expected to be a \$160 million program. Rift will be powered by the Nereus nuclear engine for nuclear vehicles applications program.

Col. Stuart Feltner, NASA's chief on loan to NASA, is the director of MBT's Nuclear Vehicle Project Office within the Propulsion and Vehicle Engineering Division. This office may become an independent project office—like Saturn Systems or Light and Medium Vehicle—once recommendations now in being given by strong operational Rift stage on Nereus as well as on Saturn C-5. Rift is scheduled to make its first flight sometime 1966-1967 in the third stage of the vehicle.

Lockheed will build separate production lines of light and ground test Rift stage elements of the approximately 15 ft. long 75 ft. diameter stage are placed under the present contract:

- Three half-scale models, with one of them designed to accept for engine tests
- Three static and test dynamic test models for use at the Nuclear Rocket Development Station at Johns Hopkins, Nev.
- Four light test vehicles, to be flown from Cape Canaveral, Fla.

First flight of Rift will be made with an inert Nereus engine. Second flight will be the first powered flight of Rift, with a live nuclear reactor flown into Cape Canaveral and mated to the orbiter in a rocket assembly building. This first static Rift will be flown from light-test house the Cape in an almost straight-up and straight-down trajectory to provide the maximum telemetry time—about 10 sec.

Rift will not be built at the present NASA-owned Michoud, La., plant because the S-4 and S-6C production line will utilize all current space. Then now on being considered to add another high bay area to the Michoud facility to accommodate Rift production as to build a complete new plant to house Rift and Nereus stages.

S-4s, designated SA-1 through SA-5, at Huntsville Chrysler will build SA-9 in a dry-out test of its manufacturing procedures and then Marshall will construct the last research-and-development, booster, SA-16. Chrysler then will build the 20 units called for in its contract.

First two Saturn boosters—SA-1 and SA-2—flew successfully last Oct. 27 and Aug. 25, respectively. Both were three-stage vehicles, as SA-3 and SA-4 also will be, but the second and third stages—SA-4 and SA-5—were and will be dry-out stages fired with water for testing.

Block-2 models of the S-1 booster will be introduced into the flight test program starting with SA-5. Block-2 version of the S-1 differs from Block-1 model, used on SA-1 through SA-4, as the following ways:

- Upgrading of the S-4 engine from 165,000 lb thrust to 185,000 lb
- Increased engine gasket capability from Block-1 ± 7 deg to ± 10 deg on Block-2
- Increased payload capacity from 750,000 lb on Block-1 to 850,000 lb on Block-2
- Addition of stabilizing fins to the Block-2 booster.

Also starting with SA-5, the Saturn C-1 will change to a two-stage, one

engine, using the S-1 (Block-2) booster and the Douglas S-4 second stage. SA-5 will be the first powered flight test of the S-4 and will be the critical test of the guidance and control system which is based on computers drawn from the Army-Mitsubishi Pershing ballistic missile.

SA-5 will carry the first uncrewed Apollo spacecraft and flights SA-6 through SA-10 will continue to test both the Saturn booster and the Titan-2 nuclear engine in earth-orbit flights.

North America's Space and Information Systems Division was selected last September to build 10 S-2 stages under an initial contract totaling \$149 million.

Originally, the S-2 was conceived as a 21-ft-4-in. dia., 74-ft long stage to be powered by four J-2 engines, for a total stage thrust of 800,000 lb.

Just when Marshall and NASA decided that plans to use four F-3 engines in the advanced Saturn booster, the S-2 was modified to make it more compatible with the first stage. Diameter was increased to 35 ft., same as the S-1C. Length was stretched to 78 ft. and a 6-in. 17-angle was added to provide a total stage thrust of 1 million lb. The S-2 has a payload capacity of 930,000 lb.

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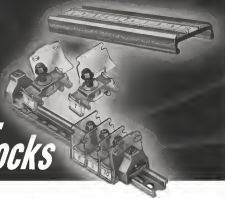
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for more occasional satellite and atmospheric probe missions.

NASA and Marshall selected the Centaur program from USAP with something less than wild enthusiasm. Despite development problems and a few-flight failure last March which have added 15 to 24 months to its original schedule, Centaur appears to be coming out of its development woods, and Marshall officials—including Wernher von Braun—have publicly declared it.

Harry Haefliger, director of light and medium vehicles project office, says that present Centaur problems do not look any more serious than those encountered in other new programs.

Haefliger has established a series of working groups—in such areas as structure, guidance and control, propulsion and launch operations procedures—with personnel drawn from Haefliger's own project office, from Marshall support divisions and the two prime contractors—General Dynamics/Armstrong for the stage and Pratt & Whitney for the engines.

Agnes-D

Unlike Centaur, where Marshall deals directly with General Dynamics, Marshall's prime contractor for its Agnes program is USAP's St-Johns Company and the actual builder of the stage—Lockheed Missile and Space Company—technically a subcontractor to USAP. All changes desired by Marshall in the latter Agnes are passed to USAP, which in turn directs Lockheed to make the changes.

Marshall is looking forward to the Agnes-D, which will have the most sophisticated and propulsive system in Agnes-B, but a simpler sequence of carrier vehicle and payload. The B developed primarily for USAP's Mars and Saturn programs, has different nose cone systems and subsystems scattered throughout the stage and their use is modified before NASA payloads can be launched efficiently.

All electronics on Agnes-D are the latest modifications of B equipment and are more securely located in the stage's basic structure. For example, the guidance system now is made forward and can be reached through a single panel. These changes have added minor weight to Agnes-D, but the vehicle project office feels that the closer location of system and greater accessibility more than compensate for it.

NASA has fine plans to use both the B and D models through at least 1965.

Marshall is in conjunction with USAP, presently is looking for an inexpensive, standardized upper stage for small payloads that would be available around 1965-1966. Whether it will be a modification of the

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and Agents to a Constant stop as Atlas or a Titan, Marshall feels strongly that there is a requirement for a more economical vehicle in the years to come.

All NASA motion has been lying straight stability requirements on contractors during the past year and Marshall has been no exception. Unlike military booster programs, where a reliability figure of 75 to 80% might be acceptable, Marshall is asking about a 100% guarantee that a launch vehicle will work when called upon. Hardware is getting too big and too expensive to afford failure.

Marshall's director, Winchell von Braun, says that reliability has three major components:

- Inherently reliable design
- Constant staring on all levels of the contractor's organization to achieve perfection. That performance in this area will be a critical element in the awarding of future contracts
- Establishment of manufacturing procedures and development of efficient equipment

Marshall has a Quality Assurance Division where all of its designs are tested exhaustively and to analyze all electrical, pneumatic, hydraulic and mechanical systems intended for use. The center also has a Reliability Office, which ties in closely with the Service Systems and Light and Medium Vehicle Project Office.

Service Guidance

Guidance and control systems for the Saturn C-1 and C-2 will be made chiefly by Marshall, using components drawn from the Jupiter and Pegasus ballistic missile systems.

The Aerospace Research Guidance and Control Division presently is developing two directed systems, including ascent and flight controls, for the following:

- Saturn C-1, for the first five or six flights of the Block I S-1 booster—SA-1 through SA-5 or SA-6. The system employs components taken from the Jupiter missile and mounted on a modified platform.

• Block I Saturn C-1 and Saturn C-2. This system, intended to be the guidance and control unit of operational Saturn vehicles, is based on acceleration, gyro and heading procedures drawn from the Pegasus weapon system. There will be several on a four-gal platform with 500 deg freedom in all planes, it is being built by Edgewood Division of Rockwell Corp., Palmdale. A full-scale facilities is designed to give Saturn a mission creep capability for redesign operations.

Heading components will be light-weighted on an open-loop basis aboard Saturns SA-3 through SA-6, but—d proved successful by SA-5—may be substituted into the complete unit to se-

services for aerospace contractors:



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Arma environmental laboratories are among the finest in the nation, originally designed for stringent testing of the all-weather guidance equipment now in operational service on Air Force ATLAS missiles. These facilities, including the world's most precise large centrifuge test unit, can now provide complete engineering evaluation services for contractors. Outstanding simulation equipment plus a competent staff of experienced engineers is available to help design and develop better, more reliable equipment and components through environmental testing.

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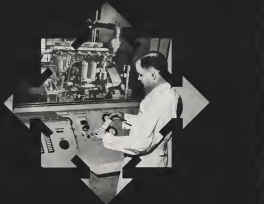
Comparable in many respects to National Bureau of Standards facilities, the Arma standards and measurement laboratory is available to outside contractors for assistance on specialized measurement problems and quality control activities. Certification of reference and working standards and maintenance of records can be provided. Facilities for electrical measurements in the radio spectrum are the finest available.

These Arma laboratories were used in the development and production of the Atlas all-weather guidance system and the B-52 fire control system. These sophisticated projects fully demonstrate Arma's qualifications to offer expert assistance to those seeking the finest in facilities, personnel, and experience.

Complete technical information on the services available is contained in a 34 page booklet titled "ARMA's Wide Corporate Government Marketing, Arma Division, American Bosch Arma Corporation, Garden City, N. Y."

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PROJECT: PROVE RELIABILITY

This research specialist is subjecting a military power package to programmed failure. Purpose...establishing design and hardware reliability. This type of proofload research was applied to the development of a 700 HP aluminum compression ignition engine weighing about four pounds per HP.

A standard procedure at Caterpillar, testing of this type is used regularly with new components, engines and vehicles. A new facility has been designed which will expedite these engine testing programs through the built-in fuel, water, exhaust, control and instrument systems.

A six-story building of 164,000 sq. ft., the new Engine Research and Development Laboratory houses a complex of 72 testing cells where a wide variety of engines can be tested.

Each cell is air conditioned to 75° Fahrenheit and is maintained at a slight vacuum. Each has its own master block to eliminate the transfer of vibration from one test zone to another. Each is completely soundproof. The researcher and the engine are separated by thick glass panels.

During testing, an automatic remote control permits the researcher to subject the engine to any of the many stresses and strains it could encounter during its work life. With the flick of a switch or the turn of a dial, the specialist can adjust the water temperature of the cooling system, the horsepower, the oil and fuel pressure, the RPM, the load and torque, or many other conditions.

The effect these changing conditions have on the engine's performance is accurately measured at the console. Test results are recorded—and often predicted—by digital and analog computers. The analysis of these results is combined with the findings of a physical examination of individual parts for ways to provide maximum reliability.

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Another building soon to be ready at the Technical Center is the Gas Turbine Engine Laboratory. Here will be housed facilities for the research group which has been exploring this exciting new engine concept for the past five years.

When the Center is completed it will consist of six buildings. It will house 1400 engineers, physicists, applied mathematicians, chemists, metallurgists, instrumentation specialists and laboratory technicians who are part of the Caterpillar research and development team.

It will provide needed additional space and facilities for the intensive research currently going on in metal fatigue, high-speed rotational phenomena, fluid mechanics, fuels and lubricants, special studies in basic materials, and dozens of other projects.

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New NASA Center Expands Cape Mission

Launch Operations Center will have increasing role in design, application of advanced launch vehicles.

Cape Canaveral-Newly established Launch Operations Center will join the Marshall Space Flight and Marshall Spacecraft centers this year as a full partner in the manned lunar launch program and also will have an increasingly greater voice in the design and use of new launch vehicles.

Starting with the present Saturn C-3 program, facilities are becoming as essential as a launch system in the flight vehicle itself. As heavier vehicles, such as Saturn C-5 or Nova, grow in size and complexity, so will the facilities and the equipment to extract the maximum use from each launch complex.

These considerations of vehicle size, launch frequency, number of launch stands, time and money and conducting the launchings themselves are the components of the mission assigned to the center and its director, Dr. Kurt H. Debus. They might be summed up this way—flow is NASA to launch more vehicles more frequently from the least amount of land at the most economical cost.

This question applies equally to all programs brought to LSC here at the Atlantic Missile Range, whether they are today's research and development projects, such as Saturn, or tomorrow's operational systems, such as Apollo. Saturn is expected to become by 1965-1966.

As making a near-future here when its activities at Cape Canaveral will take on more of an operational color and less of a research-and-development shade, NASA decided earlier this year to separate the Launch Operations Directorate from Marshall and establish it as an independent center. This separation was scheduled to become effective July 1.

Lower Landing Program

Interactions between the center and Huntsville and Houston were also being defined. That will fix the Launch Operations Center's precise sphere of responsibility in the manned lunar landing program. Marshall Spacecraft Center is charged with development of the Apollo spacecraft and Marshall with the development of the Saturn C-5 launch vehicle.

To Debus' center probably will go the task of assembling the complete Apollo-Saturn vehicle and then launching it at least through the powered flight at the down-stage Saturn-on-reel as scheduling launch windows with the Atlantic Missile Range and conducting all NASA support requirements to be aided at the range. The center here will report directly to Brainerd Holmes' Office of Manned Space Flight at NASA head offices.

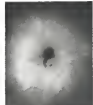
Debus presently is building his organ-

izational structure. It is expected to resemble that of Huntsville and Houston with support offices in two broad areas—facilities and ground support equipment—and two system offices—policy and vehicle space vehicles—plus the usual administrative and financial offices.

There also will be a technical staff of specialists in such areas as payload, vehicle systems and launch and exposure damage, reporting directly to Debus. A reliability office and an industrial relations office also are among possibilities.

Field Office

Debus expects to have a field office of about 50 personnel, under Theodore Popple stationed at Huntsville to see that operational launch requirements are incorporated into the design of new launch vehicle systems and that vehicle design parameters are met by the ground support equipment planned for installation at the Cape. Marshall will have a field office attached to the center here, eventually for the same purpose as the launch center's office at



SATURN C-2 lifts off in Apr. 25 test, right. Its control stand, shown was forced at 65 in. altitude by blowing water behind. S-3 was deliberately destroyed.



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Pacific Launch Operations Office

Seven Nimbus meteorological satellites and seven scientific payloads are planned for launch into polar orbit by the National Aeronautics and Space Administration over the next two years from the Pacific Missile Range.

Pacific Launch Operations Office has been established by NASA at Ft. Aguigle, Calif., to coordinate the agency's requirements at PMR with Navy and USAF. Office has the use of four Thor-Agena B launch stands at Vandenberg AFB and two Atlas-Agena B stands at nearby Ft. Aguigle. NASA has its own Scout launch area just at Ft. Aguigle.

Pacific office, which reports to the director of the Office of Space Sciences, is staffed presently with about 15 people. There are field offices of Goddard Space Flight Center (main payload), Marshall Space Flight Center (sat) and Langley Research Center (sat) attached to the office.

Very made available hall of a mobile assembly building at Ft. Aguigle for a NASA spacecraft laboratory. There with 4000 sq ft of laboratory space and 10-100 sq ft high bay area, facilities are checked out. Instruments tested and systems simulated to the extent of the ground support equipment provided by the customer or payload developer.

Pacific office has one floor in a building adjacent to the laboratory and there, in addition to administrative offices, it is a building a major operations center. The mission director—down from the center responsible for the payload—will control the flight of his payloads from this center through data display on plotting boards and consoles.

A 100 ft tall antenna tower is being built alongside the spacecraft laboratory to allow direct communication between the mission operations center and spacecraft sitting on stands at Vandenberg, a 310 ft tall ridge presently separates the two sites.

Hardware and also to monitor the conditions of stages applied to the Cape from Marshall supported production plants.

Philco's office of the launch Center will be responsible for the look and monitor construction of launch complex, support structures, launch site test systems and the virtual assembly building. It will work closely with the Army Corps of Engineers, the actual construction agent. Ground support equipment office will be charged with integration of computers and checkout equipment on the different vehicle line.

Along and assembly buildings, payload storage and transfer station, the launch table—assembly support and hold-down area—and display equipment in launch control center and blockhouse.

In the future office, the heavy vehicle launch will assemble, check out and launch the Saturn C-1 and C-5.

Nova and RLV vehicles. The Saturn C-5 with a RLV third stage about to be called a Saturn D. Medium vehicle office will be engaged to handle Thor-Agena, Atlas-Agena and Atlas-Centaur boosters.

Dolan's center deals with Air Force Missile Test Center, successor of the Atlantic Missile Range, through a Test Support Office, under USAF Col. Aubrey Cobble, who is on loan to NASA Test Support Office; gathers the requirements of all NASA work on the Cape, ranging from raw needs to refurbishing proposed launch sites to building and testing these needs to AFMTC in a related package. Conflicts among the different NASA offices are sorted out before reports are laid on AFMTC.

AFMTC is responsible for a build-up of the range as growth, NASA for facilities needed for specific missions. All AFMTC support is reimbursable.

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for, made, sites, communications and instrumentation, telemetry and tracking is accomplished in a Mission Planning Board, which directs operations from AFMTC and other military agencies, the Launch Operations Center and Air Force, contract operators of the stage. Orbits of a space time to calculate the actual equipment or facility he will require and the date, and AFMTC then cranks the requirement into its future plans. Planning Board is perhaps the most important of several joint USAF - NASA - contractor working groups.

To preclude the growth of large, separate NASA launch plans for each launch vehicle system, the launch center intends to great care and more pullback and launch responsibility in vehicle construction. As a vehicle leaves research and development and approaches operational status, center launch specialists gradually will open off that vehicle and transfer to a new vehicle just beginning its flight test program.

The contractor, probably the vehicle system manager, probably will be placed into the operation and be thoroughly trained in the center's procedures, philosophies and policies. Eventually, when a vehicle has reached operational status, its launch complex will be staffed about 90% by contractor personnel. The center will retain control and authority of the vehicle, and the NASA center providing the payload in the vehicle may direct the mission—but the launch and powered flight of the vehicle will be executed by the contractor.

Launch Operations Center presently has about 600 personnel, of which some 200 are engineers or technicians. Debus hopes to add another 150 to 160 more to his center, that final year, bringing total strength up to around 800 by next summer.

Attached to the center's organization, but not line employees of it, are the

AMR Center

Cape Canaveral, Fla.-National Aeronautics and Space Administration's operating element has recently was moved to a modern and a solid Launch Operations Center. NASA is acquiring 40,000 acres here for Station and New Launch complex line, and new other Atlantic Missile Range facilities jointly with the Air Force.

The center has an operating budget request of \$127 million for Fiscal Year 1969, with supplemental funding 703, which is 210 more than last year. Budget request is about 33 million.

NASA has asked for \$500 million to construct new launch facilities here during Fiscal 1969.

BRINGING OUTER SPACE "DOWN TO EARTH"



(Dr. Reliability revisited)

Norm Frenkel (pronounce it as though there were only one "f") tells a story that sticks in the mind. A short while ago, Norm, who heads up Test Facilities Engineering at Budd Electronics, was discussing with his Force General the various and sundry inputs required for reliability testing of spacecraft. The General suddenly stopped, looked at Norm and said, "I've known what we really need to build." As one of the room.

With due regard for the General's inspired epiphany, we've seen there are many others who long for a shot at better environments here on terra firma. What makes the idea so memorable is that it pretty well sums up the whole problem of getting our spacecraft... and our spacecraft... in their demanding and testing from their 100% reliability.

The problem basically is one of getting enough operational failure mode data (i.e. how often does it fail?) Getting it from actual launchings is too costly and too slow... add, in the case of manned craft, unfathomable. Some of it we can get from single-launch testing of minimum and maximum... but statistical extrapolation... from system elements under static forces to adapt systems and complete vehicles is available actual experience... is not going to serve as 100% perfect reliability. We may have a good idea of the type and magnitude of the space force envelope, but what about the

complex interacting and interdependent stresses it produces on spacecraft? The solution... it becomes clearer every day... has got to come down to total simulation of space environments.

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Field Projects Branch Office of Goddard Space Flight Center, Flight Operations Division at Marshall Spaceflight Center, Jet Propulsion Laboratory field office and Launch Operations Division field office of Marshall.

Goddard has 24 people stationed at the Cape under Robert H. Gray and their job is to prepare both launch vehicle and complex for the flight of an unknown number of satellite programs. The Delta launch vehicle is brought directly from Douglas, the vehicle instruction message, by Goddard.

Goddard has 27 Deltas ordered, 10 of which have been used already, for programs extending through Fiscal 1965-Term, February, Big Star, Relay, Syncom and several scientific satellites.

First 12 Deltas have the 150,000 lb thrust Rocketdome engine in the Thor stage; starting with Delta 13, the uprated 165,000 lb engine will be substituted instead. Delta 17 will see the introduction of an improved second stage, designated A130-115-A, it will be 76 in. longer than its predecessor and not inhibited red instead of white—finning, antic and (JRNAN) in order. Delta 13 and 14 will be a version of new first stage and old second and third stages.

Goddard's Field Projects Branch has been sharing Complex 17 with USAF's Space Systems Division. There are two stacks at Complex 17, A and B, with Goddard using A for the first 10 Deltas and USAF using B for the Thor Ablestar Scouters and Transit, Arma, Courier and Comstar payloads. Because of the heavy launch schedule being at this year Goddard will be allowed to use 17 B whenever it is needed and whenever USAF can make it available—starting with Delta 11. Launch areas are usually Douglas personnel, with Field Projects Branch Chief Robert Gray directing the launch and a Greenbelt team supervising the mission.

When Goddard's Executive General Office (EGO) and Goddard's Astronautical Observatory (DAO) come along, Field Projects will see Atlas Agena vehicles instead of the Delta. There also are some vague plans to use Atlas-Centaur and possibly even Saturn for some scientific satellites.

Jet Propulsion Laboratory has a small office here to check out their payloads and compare them against Marshall-provided launch vehicles. At the time of a launch, JPL acts as the mission director with a launch center staff—experts Delta—acting as test director and General Dynamics/Astronautics and USAF personnel as test conductors.

Marshall's Flight Operations Division, as the title implies, is responsible for preparation of launched payloads and manned spacecraft before flight operations.



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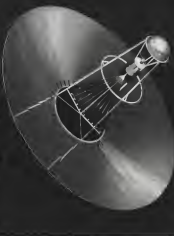
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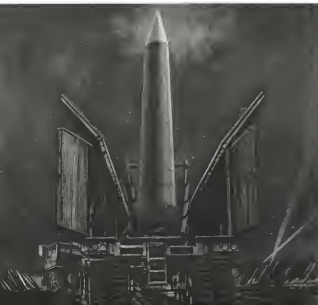
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NASA Building Flexible Cape Facilities

Cape Canaveral-Facilities being planned here for the Advanced Saturn, RLV and Nova vehicles reflect the National Aeronautics and Space Administration's intention to have the future exploration of space on a flexible and quick-response launch capability.

Launch complex for the Saturn C-5 and Nova are being designed as integral parts of the complete launch system and will make maximum use of the experience gained from design and construction of the first Saturn facilities—Complexes 14 and 37—for the C-1 vehicles.

Three Saturn launch complexes are now planned for the Atlantic Missile Range:

• Complex 39, with four stands for the Saturn C-5 vehicle.

• Complex 37, with two stands for the Block-2 model of Saturn C-1.

• Complex 34, with one stand for the large Block-1 Saturn C-1 vehicles. It will be converted for Block-2 Saturn C-1s.

Nova launch facilities are still in a very fluid study phase and are dependent on final vehicle configuration and intended operational use.

NASA's launch complexes presently planned or building at AMR include, from north to south: Gemini Titan 2 at Complex 39, Complex 34, Complex 37, about 3,800 ft. north of 34, and Complex 36, about 20,000 ft. north of 37. Nova sites are being investigated and probably will be several miles farther north of Complex 39. USAP, which houses the Air Force Missile Test Center, presently plans to build three Titan 3 launch stands between

Complex 37 and 39. Little Joe 2, a suborbital booster to be Apollo suborbital trajectories, may be launched at the Cape or at White Sands, N. M.

Service center of Complex 39 will be central assembly building, where the three stages of Saturn C-5, the Apollo spacecraft and its modules will be vertically assembled prior to movement out to a launch stand. The 400-450 ft. tall building possesses a container as a series of unmodulated high bay areas which can be built in steps. It is likely that only four bays will be built at first. Two more bays, with higher ceilings than the first four, probably will be built later for growth version of the C-5, such as an Advanced Saturn with a nuclear third stage.

Five control bays will be built in line and each will open either on a large stand or coal—depending on the type of transporter-launcher selected. Extra-high bays would be added to the end of the building facing the launch stands.

At the far end of the building will

be a launch control center, which will direct all activities in the complex area, and a low bay area for cargo-delivery of the S-IC, S-2 and S-4 stages. Stages are to be delivered in a flight readiness condition and, after an acceptance check and pre-launch preparations in the low bay area, will be moved by overhead cranes into a high bay for assembly with other stages. Design criteria of the central assembly building are expected to be completed by this fall and a competition held for an architectural and engineering contractor.

At the base of each bay will be a transporter-launcher, a variable platform upon which the Saturn C-5 will be assembled, moved to the launch area and fired.

Each launch stand, upon which the transporter will rest, will have its own liquid oxygen and liquid hydrogen storage tanks. Stages now are being made of the best way to bring propellants from the central storage area to the launch area—large, pipeline or railroad car.

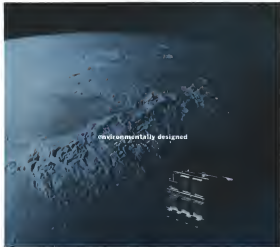
The stand will include a dry-launch flame deflector, but not a launch pedestal that will be one of the two functions of the transporter-launcher.

Three types of transporter-launchers are under close examination and are favored in this order:

• Carrier, as studied for Launch Operations Center by the Bureau of

TITAN 3 Complex 39 of the Atlantic Missile Range is now being modified to accommodate the two-man Gemini spacecraft payload.





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Provision of the Titan 2 booster for the two-man Gemini spacecraft will follow procedures similar to those used by the Naval Aeronautics and Space Administration and Air Force in procurement of the Atlas vehicle in the Mercury program.

USAF's Ballistic Systems Division will be headed by NASA's Manned Spacecraft Center for fabrication, assembly and preparation for flight of the Martin Titan 2 missile. Tasking will be built at Martin's El Segundo, Calif., facility but assembly of the Ballistics, Md., plant. USAF also will be responsible for activation of Titan 2 on the launch stand, automatic launch and powered flight of the vehicle, under NASA's direction.

Manned Spacecraft Center will assign a permanent plant representative to Martin-Ballistics to coordinate assembly of Titan 2 boosters and a representative, who will travel between Hamilton Divisor, Baltimore; Los Angeles and Cape Canaveral. He will keep the spacecraft center apprised of vehicle status and keep USAF, Aerospace Corp. and Martin aware of NASA's thinking.

Two weeks before scheduled delivery of a Titan 2 to the spacecraft center's Flight Operations Division at the Cape, an engineer from the Cape division will travel to Baltimore to review the history of the particular vehicle to be delivered and then with it and its assembly line. The engineer is expected to become thoroughly familiar with the booster's individual characteristics.

Crewing program also will need a combination of two management groups authorized for Mercury.

• Booster working group, composed by USAF's 555th Test Wing at the Cape, will include major Titan contractors (Martin, Aerojet-General, AC Spark Plug and IBM) and NASA

Titan 2 for Gemini

representatives. This group presently is concerned with booster and launch complex matters.

• Mission working group, composed by the spacecraft center at the Cape, will coordinate Flight Operations personnel. Boeing project people, USAF representatives, both from BMD and Atlantic Missile Range and a team organized from Martin and Aerojet-General, El Segundo, will be concerned with test activities in spacecraft-launcher mating procedures, weight test procedures, detailed scheduling of tasks and resolution of particular hardware problems, i.e., incompatibilities between Titan 2 and Gemini systems or between ground support equipment and the complete vehicle.

Only significant differences between handling of Titan 2 and Atlas at the Cape will be the formulation of Flight Operations from Division's technical capabilities to monitor launcher dual aspect.

Under Mercury, USAF officially was completely responsible for all launcher work and presented only the results of its work to NASA for approval. In earlier, there was much informal cross talk between USAF representatives and NASA engineers from different payload offices and proposed modifications to the launcher system were discussed thoroughly before the proposal actually passed through USAF-NASA channels.

For Gemini, these payload offices will be breakdown into functional groups to deal with Titan 2 development can be repeated. USAF itself will be responsible for initiation of booster improvements and will continue to channel proposals up through BMD headquarters to Manned Spacecraft Center head quarters in Houston, but will have the benefit of NASA inputs at the working level.

Co., the crawler was conceived as a two-part vehicle—an assembly and launch table mounted on a tracked-disk drive belt launcher. When the Apollo-Saturn was ready to roll to the launch stand, the crawler would raise several 60-m-dia hydraulic pistons to clear the launch pit and then move out of the bay area onto a concrete road for the 2.75 mi trip at a speed of about 1 mph.

At the launch stand, the crawler would retract its supporting pistons and lower the launch table onto the stand. It then would drive out from beneath the pit and return to the assembly building. Total weight of the crawler vehicle, including the launch Saturn vehicle, is estimated at 1 million lb.

• Barge. A series of canals would connect the various assembly buildings to the launch stands in this concept and the Apollo-Saturn would be built on moved in and launched from a barge approximately 180 ft long, 110 ft wide and 25 ft deep. The completely assembled vehicle would be moved through the canals in a launch stand, which would essentially be a lock. Once the barge was properly positioned, the lock would be closed, the water pumped out and the barge allowed to settle on the stand supports. Weight of this system, including the rough launch vehicle, is estimated at slightly more than 5 million lb.

• Rail. This system would be similar to the crawler concept, but would use rails instead of a road. Weight is estimated to be around 10 million lb.

NASA Operations Center personnel feel the rail technique has several advantages, but in addition to its greater weight. Barge plan causes some apprehension because of the very fine sand which on which the system must move. Crawler presently uses the rough, irregular approach because it allows a solid medium on which to move and the ability to remove the locomotive from the launching effort of the Saturn's return.

Regardless of the system chosen, the center has decided that the transporter-launcher will contain three essential elements.

• Digital computer system carried in the base of the transporter and used as the primary check of checklist operation for the launch vehicle. This system will begin an automatic check-out of the vehicle stage-by-stage, in each stage of the Saturn C-5 is brought into the bay and assembled. Once the transporter begins movement of the vehicle from the assembly building to the launch area, one of two launch control operations in the Launch Control Center will become operative. One of the vehicle will be moved to the launch area by the transporter's computer system

over a digital link. Transporter computer system will continue to monitor the vehicle through the count-down and —being test protocol and check-out—during the three-second hold-down after engine start. The T-1 engines. Computer in the transporter will be almost identical with those in Launch Control Center.

• Unfilled dome, about 350 ft tall, will be located above the launch area. The vehicle in the transporter. Tower will contain an elevator for personnel and flexible using areas for each stage and the spacecraft. Area will hold personnel catwalks and ladders for pre-launch loading, checkout, jacking and gas lines for purging, heating and cooling. Hydrogen boil-off from the C-3 and S-4B stages will be piped off the vehicle across three venting areas, aimed from the tower and dumped away from the launch area. Inter-stage structures will be big enough to allow maintenance men to enter and work on stage without it necessary. Personnel platforms within interstage structures will be removed through access doors prior to final preparation of the vehicle for launch.

• Support and hold-down area will be built into the launch table. Present Launch Operations Center Marshall Island plans to fear of each for Saturn C-5, with the support area re-



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tracted during the first 3 sec. of flight.

An entrance tower will be located midway between the vertical assembly building and the launch area and the transporter will stop there to allow the escape tower to be added to the Apollo spacecraft and all other postflight devices to be installed.

Using the vertical assembly method, the worker expects to cut the time spent by the launch vehicle on a stand waiting for flight from C-1's present figure of two to three months to less than a week. Assembly time for the C-1 in the vertical facility also should be considerably less than assembly time for C-1 in the pad because of the structural convenience and extensive use of integrated checkout equipment.

Vertical assembly building plus four launch stands will provide NASA with considerable flexibility in scheduling the manned lunar landing program. For the emergency mode of readiness, for example, the orbital module could be set up on Stand 1 and two manned Apollo vehicles prepared on Stands 3 and 4, with Stand 2 held in reserve as a backup stand for either the tanker or a manned vehicle. Should any of the three prime vehicles be unable to proceed with the mission, it could be rolled out of the launch area and a new vehicle brought in from the vertical assembly building. Distance between each stand is expected to be 3,000-41,000 ft.

For lunar rendezvous, where only one C-1 vehicle would be required, launch-stand construction will be eased considerably. One or two backup vehicles could be prepared for possible replacement of the primary Apollo-Saturn.

Only loading factor in the launch frequency rate of Complex 19 would be the time-on-station time of stage stacking and maintenance. Three vehicles, two Saturn C-1 could be launched within minutes of each other. Actually, it would require several hours.

Block-2 models of the Saturn C-1 will be flown from two launch tables-A and B at Complex 17. A-1 and B-1 stands are separated by 1,200 ft. Only one vehicle will be on either stand at a time to preclude the loss of two Saturns if an explosive failure should occur.

Vehicles will be assembled by a self-mounted service tower, which will be able to roll back and forth between 37A and 37B. Towers will have a swingover cranes that can encase a complete Saturn C-1 so that work may go on under any weather conditions. After weighing a launch vehicle on 37A (or B), the tower will be rolled back to the other stand to minimize damage in the event of a failure at launch.

The first facility built to launch a Saturn vehicle, Complex 14 will be

two more Block-1 models of the C-1 vehicle, SA-1 and SA-4. At SA-4, the first of the Block-2 vehicles, and SA-6 by June Complex 17, the older complex will be modified to take Block-2 vehicles.

Modifications to Complex 14 include the construction and installation of a liquid hydrogen ground storage tank for the 48 stage, an increased high pressure gas capacity and construction of a 140-ft. tall auxiliary tower with swing arms for the first and second stages and the Apollo spacecraft. Launch pedestal also will be modified by the replacement of the four support arms used for the Block-1 C-1 with eight arms used for Block-2 vehicles. Auxiliary tower will be ready by the time SA-1 flies later this year and the hydrogen ground storage tanks will be begun soon.

Conservative estimates of the launch rates are four per year for Complex 14 and six per year for Complex 17. First flight of a Block-2 C-1 from Complex 17 will occur early in 1963.

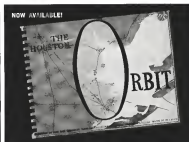
Part of the 72,614 acres adjacent to the present Cape area to be acquired by NASA (AW Feb. 12, p. 31) will be used for an industrial site in the north end of Merritt Island. A spacecraft preparation building is to be constructed there by the Manned Spacecraft Center and another building by its side will be used by the Launch Operations and Marshall center and contractors. Both will be combined office and laboratory structures. The area also will include storage warehouses, a processing building, dispensary and cafeteria.

NASA expects to announce a Request for proposal to select an architect and engineering firm for design soon.

Consideration is being given to the installation of some low-orbit test facilities on Merritt Island, but plans are not yet definite. Sites would house infrared and acceleration equipment for a precise test during the first several hundred feet of powered flight.

NASA does not plan to build a liquid hydrogen plant at the Cape, believing it will be cheaper to buy bulk lots and have it trucked into storage area. The liquid oxygen plant now at the Cape will be expanded significantly.

NASA has acquired all the beach land for about 28 mi north of the Cape's present northern boundary. This will be used for Saturn C-5 and Nova sites and was considered first priority for acquisition. NASA Administrator James E. Webb recently announced the agency's intention to acquire another 14,000 acres beyond this 20 mi zone, since the construction of three launch stands will demand a wide open area on either side of the USAR facility and reach Saturn C-5 and Nova area and further north. The Cape recreation now will extend from Brevard to Volusia counties.



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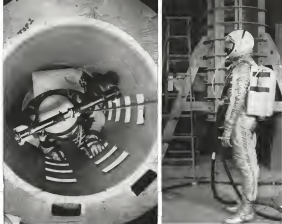


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MANNED SPACECRAFT CENTER engineer, wearing a spacesuit with a mockup environmental control suit on his back, tests one of six sensors within a mockup tube simulating the airlock in the Apollo capsule. These tests at the Manned Spacecraft Center are designed to provide data on optimum sizes of the control suit and the airlock.

NASA Bioastronautics Role Still Unclear

National Aeronautics and Space Administration and Department of Defense so far have failed to reach agreement on the extent of bioastronautic support to be provided by the latter for civilian manned space flight programs and the resultant impact probably will go now to top Administration officials for resolution.

There is no doubt that Defense's bioastronautic capabilities are to be used in Gemini and Apollo. The question is—how? NASA would like to make maximum use of Defense facilities and personnel on a tailfeet basis. Although Defense presently is accepting task assignments from NASA, it claims that continuation will fragment the bioastronautic structure that has been built up over the years.

Defense has been urging NASA to accept package responsibility for bioastronautic support of manned space flight to the military and to use total USAF-Mary-Kerry resources and personnel as its cadre—or if it were another NASA division.

NASA has rejected this on the ground that NASA must have some of its own capability in this field, since bioastronautics is as essential an element of mission success in spacecraft or bomber development.

NASA's position was most clearly stated by Deputy Administrator Hugh L. Dryden before the House Committee on Science and Astronautics: "Some capabilities must be provided within NASA itself. It would be hazardous for any organization to accept responsibility for the manned exploration of space without the acquisition of some competence in one of the main fields on which success depends."

"It is not possible to delegate complete responsibility for an entire technol-

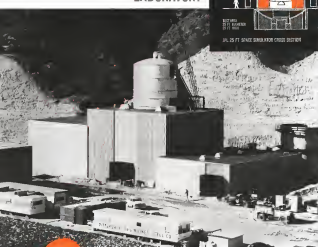
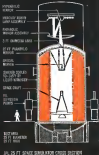
cal field to some other group, although it is possible and desirable to delegate the largest part of the execution of the program to other agencies, including industry, universities and other government agencies as appropriate."

Dryden also said: "I do not think the complete responsibility of bioastronautics can be assigned to the Department of Defense any more than any branch of our weapons system support could be or would be assigned by Defense to some other agency."

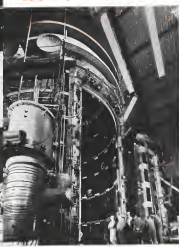
Underlying this disagreement are spheres of managerial responsibility and two major factors—operation of bioastronautic facilities and USAF's manned space program.

NASA has long contended that Defense's present facilities are not large enough to cope with the bioastronautic work that will be required for Gemini and Apollo and that considerable expansion will be necessary. Defense has agreed that growth is required but agrees that it should be built

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RAYTHEON will build APOLLO Guidance Computer

NASA has selected Raytheon's Missile and Space Division to produce the digital guidance computer for the APOLLO manned lunar exploration program. This computer, located in the spacecraft, will serve as the mission nerve center during the entire APOLLO flight. It will receive the signals of each of the guidance system's sensors.

Data will be processed by the computer for automatic control of certain flight functions and for presentation to the crew to permit the optimum exercise of human intelligence during the mission. The computer will be used for all phases of the APOLLO mission.

Under its NASA contract, Raytheon will provide engineering support on the computer design

to the D.I.T. Instrumentation Laboratory, which has design responsibility for the complete APOLLO guidance system. In addition, Raytheon will produce the computers which will be used on APOLLO flights.

The selection of Raytheon for this key role in the APOLLO program is but one indication of Raytheon's rapidly expanding space program and demonstrates that in the space age, as in the past, Raytheon means Excellence in Electronics.

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around existing tools to save time and money.

NASA is chary of providing Defense with funds to accomplish this, for fear that this would only strengthen USAF's drive for complete management responsibility.

On this matter, Dr. Dryden told the committee: "We have taken the position that none of these [expanded] facilities were for either NASA, that since probably will be at existing laboratories of the Department of Defense And, in any case, we are freely agreed that the existing facilities should be used to the fullest extent possible. Our only question relates to the necessary expansion of this effort and to questions of management."

Defense, on the other hand, is less apt to expand facilities without guarantees that they will be used fully and efficiently. Porosity of a series of leaks through the tests is no such guarantee, Defense feels.

USAF appears to have two primary unmet space flight goals at present. The manned Space vehicle (AW June 4, p. 14) and Project MOOSE, for Manned Orbital Space Station. Both programs, if they are approved, will almost certainly be manned by astronauts, capabilities to such an extent that the only support for NASA's program would be on a task-by-task basis. But these programs are not yet firm and their impact has yet to be determined.

Many biostatic observations, with both NASA and Defense, think it means that, while the top levels of the two agencies disagree, the laboratory levels of each organization often work together in harmony.

NASA Biostatics

NASA's biostatic work, today is divided among three separate offices.

• **Autospace Medicine**, under the direction of Brig. Gen. Charles H. Kennedy, USAF, officer on leave at the agency, in the Office of Manned Space Flight.

• **Research Programs**, under Dr. On F. Revell, in the Office of Space Sciences.

• **Research and Technology**, to be located in the Office of Advanced Research and Technology. Director's position has been vacant since Alfred M. Mayo resigned from NASA late in May. Mayo had been appointed to organize the office.

Manned Spacecraft Center at Houston has two important biostatic groups: the Life Systems Division, under Lt. Col. Stanley C. White, USAF physician loaned to NASA, in the Directorate of Research and Development, and the Autospace Medical Operations Office, under Lt. Col. Charles A. Berry, another USAF medical officer detailed to NASA, in the Operations

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Directorate. Both groups report through Houston to Koudoun's office.

Aerospace Research Center primarily reports and coordinates the programs of the Directorate and Technology office.

While House-appointed panel which reviewed the nation's biotechnology capabilities last year was critical of the fact that there is no central office for NASA to coordinate all its life science efforts, Associate Administrator Robert C. Scoburn, Jr., performs this function along with all the other responsibilities, but does not feel a top-level office should be assigned to the task.

Coy Roudoun's office is responsible for all aerospace medical support of the Mercury, Gemini and Apollo programs, and also future NASA manned space flight programs. There are two major components of this center:

- Research and development, test and evaluation of all life support systems—environment control, space suits and related equipment, nutrition, waste removal and radiation protection—that go into a manned spacecraft. This work, as well as the determination of human impact for future pilots and astronauts, is coordinated by Dr. Walter's division at Houston.
- Operational support of existing programs, to be done by Dr. Berry's group, will include medical selection and care of pilots, preparation and instruction of pilots into spaceflight, worldwide medical monitoring of pilots in flight, medical aspects of recovery, and data reduction and analysis of biomedical data taken during a flight.

Dr. Walter has about 160 personnel—some of whom are physicians and more than 50 with engineering or medically-related degrees—in four branches—biomedical, behavioral sciences system support, crew equipment and human engineering.

Biomedical branch is used primarily to develop criteria for various elements of space flight—pilot physiology and physiology, life support, drug, nutrition, and selection and retention of astronauts, flight, tolerable acceleration forces, gas pressures and components and nutrition.

This branch is doing considerable research into medical branches with the Atomic Energy Commission and USAF's School of Aviation Medicine. Projects include an integrating document, which would show the total amount of radiation absorbed by a pilot during flight, effects of ionized radiation on different structural materials and on different drugs. A particle accelerator will be used for the structural material tests.

Crew equipment branch is concerned with spaceflight environmental control systems and escape, restraint and personal equipment. Much of this unit's work is structured by requirements

identified by the biomedical branch.

The crew equipment branch is primarily engaged in development of space suits for Gemini, Apollo and other vehicles missions. Gemini suits being developed by B. F. Goodrich Co., will consist of three sections—torso, arms and legs. Arms, legs and helmet will be quick-detachable. Unlike Mercury, where the astronaut was considered the primary pressure vessel and the pilot's suit a backup, Gemini suits will be the prime pressure containers. Crew pressure will be dropped if one pilot leaves the suit in flight to test movement and working conditions in free space.

For Apollo, present NASA thinking tends toward a concept that would be worn inside the capsule during flight and an extravehicular garment that would replace the overall before a pilot left the spacecraft. A backpack would provide the pilot with oxygen, water and communications for exploration of the lunar surface.

For Apollo, the crew equipment branch is planning a capsule atmosphere of 95% oxygen and 5% nitrogen at approximately one atmosphere pressure. Studies of different compositions and pressures are planned, as well as the effects on the human body of pure oxygen inhalation during high exposures.

Human Engineering

Human engineering group takes the work of its sister branches and tries to determine if equipment has met the criteria of usability and whether all equipment loads add to human stress. Technical services branch is a pool of technicians assigned as needed to the other branches.

One of the most important and immediate jobs facing Dr. Berry and his branch group of five is the medical selection of 10 new pilots for the Gemini and Apollo programs. The pilots are expected to be selected in September and Dr. Berry believes they generally will be younger by 5 to 10 years than the Mercury pilots because of program lead times. There is a strong possibility that a physician as medical consultant will be included in this group. Consideration also is being given to the flight-training of an astronaut or groundcrew for future flights.

Unlike Mercury, where pilots were trained first for basic biomedical data and trained in various life support systems at each training station and ship around the world during a flight.

Dr. Berry's Aerospace Medical Operations Office also will be responsible for the training of flight medical monitors, two of whom will be stationed at each training station and ship around the world during a flight.

Dr. Berry's office will have two

branches—an astronaut crew and training flight element at Cape Canaveral and a future piloted vehicle at Houston. Cape field office, now headed by Capt. Howard Menner, USAF physician, will have at least three doctors as a sort of group practice for pilots undergoing training there. Field office also will check out life support systems of spacecraft after delivery to the Cape and make tests of critical elements.

In supporting these two operations, Coy Roudoun's office attempts to bring certain data not only to all critical branches but also directly to White at Berry, but that they are concerned in depth.

To Gen. Roudoun's office also has been the assignment of conducting with Defense Dept. studies as a joint bioastronaut program that will support Gemini, Apollo and DeepStar. Defense suggested a list of 10 tasks applicable to all three programs. After series of joint commitments on issue, the list to 50 items. Defense will give these tasks using NASA funds.

Only two items proved to be controversial. Defense wanted to fly some animals at higher altitude altitudes—starting near the end of the atmosphere where it is not possible for humans to participate. The focus also proposed to fly some extra medical facilities to determine the amount of spacecraft dwelling against an astronaut protection, but NASA wanted this data could be obtained on the ground using a parabolic accelerometer. These two items were dropped when NASA's plan for Fiscal 1967 is set. The fact that the problem agency intended to perform these jobs will be in contact with them directly with industry.

Although these 10 tasks have been agreed to at NASA/USAF working levels, lack of precise definition of management responsibility—the case of the NASA/Defense conflict in holding up information of the work.

Research and Technology Office, established within the last several months, is concerned with early with manned space flight but with man in a space environment, such as crew members in a permanent space station or at a lunar base. The office is not on critical training or pilot preparation project, but tries to identify and develop future life support needs.

This kind of work, Research and Technology plans to spend about \$20 million through the Ames, Langley, Houston, Marshall and Edwards centers in these areas:

- Effects of space flight on the human organism. Acceleration, sensory deprivation, heat, noise, radiation, aging, nutrition and atmosphere will be studied under real or simulated conditions, to measure man's performance and how it can be improved.
- Life support systems and the selection

of such things as communications, sleep, food, drugs, etc., to man's performance capabilities and their effects on modification to improve that capability.

- Manned systems integration, to answer such questions as, how does man operate an automatic instrument? How does he use that data as the cause of his flight to make his own response to his vehicle? These studies will attempt to optimize design of spacecraft systems from a pilot's point of view.
- Applied physiology and behavioral psychology.

Through these studies, Research and Technology will attempt to lay the groundwork for long duration missions—right from the start, on a number, combining both the man and the machine in orbit.

Search for extra-terrestrial life and basic research into the effects of space flight on man's environment on living organisms are the two basic goals of the Aerospace Office in the Office of Space Sciences. Bioastronautics director is Dr. Dr. E. Roudoun. The Bioastronautics office has two branches:

- Radiobiology, under Dr. Francesco H. Ghera, is concerned with the identification of extra-terrestrial life forms, the study of the effects of earth-based life through biotechnology, the survival of man in space, search for microbes in the upper atmosphere through biological experiments, infrared spectroscopic identification of Venus and Mars by a 30-in. telescope, based on board a balloon and life detection in order to be flown onboard Mariner II and Voyager spacecraft in 1964 and 1966, respectively.

• Environmental biology, under Dr. Dale W. Jenkins, is interested in the effects of space environment on life in long duration and types of earth life that could exist in other atmospheres.

• Physiological biology, under Dr. George F. Johnson, is concerned with new implants and devices in human body that can accurately measurements of such parameters as blood samples, hormone flows and ammonia can be made directly and simply in space. It also is concerned with fundamental studies of organism cardiovascular system and the central nervous system.

• Behavioral biology, presently vacant, will study the reactions of organisms to different environments and the adaptation, from testing and communication capabilities of various birds, insects and rodents leading to possible application to manned systems.

Last year the bioastronaut office noted about 30 study contracts, split about evenly between industry and universities, with a worth of about \$2.5 million. Contracts and total dollar figure are expected to double this year.

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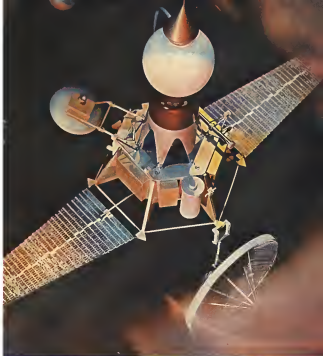
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Space Science Probes Secrets of Universe

NASA work ranges from gathering of basic physical data to supporting research for manned exploration.

Wilmington—Gathering of fundamental physical knowledge of the universe and man's solution to it continues to climb the steeply accelerating curve made possible by the first sounding rockets 17 years ago and the advent of artificial earth satellites in 1957.

This direct measurement of the planets and interplanetary environment is entering a new phase through the use of complex orbiting observations and the first of the probes that will take relatively close looks at Venus and Mars.

Space science is true basic research embracing all the scientific disciplines and such elements but covering questions in the origin of life and the origin of the universe.

But its findings can be immediately and vitally applicable—discovery of the hostile radiation belts, prediction of solar flares that might produce harmful light to the moon or at the least require heavy shielding that must be incorporated early in the design and development of the spacecraft that will carry men.

Scientific research provided the impetus for this space effort in the first place, and the National Aeronautics and Space Administration drew a key part of its operational program from the work of civilian sounding rocket and satellite teams when it was formed late in 1958.

NASA's space science activity is directed by Dr. Homer E. Newell, a veteran of Navy rocket work and the first U. S. satellite programs, began for the International Geophysical Year.

Strenus Reined

In the major assumption at NASA headquarters last November, set off by the addition of national house-keeping to the NASA mission, the agency reined the storm of space science to that of a major effort equal to those for manned flight, exploration, advanced research and technology, and tracking and data acquisition.

Astronaut Director Robert C. Seamans, Jr., and NASA felt that in its first two years of organizing and spending a rapidly expanding space program, it had concentrated too hard on technology and had not made the most of scientific potential.

NASA's budget targets for the fiscal year that began July 1 included \$150 million for the Office of Space Science, \$150 million more than the fiscal 1962 appropriation and more than double the cost of the fiscal 1961 science program. Most of the increase is for basic and observational probes that have reached or are nearing flight status and for the larger, more expensive observatory-type satellites.

The lunar and planetary programs to cost approximately \$250 million this year and the scientific satellite program \$175 million. Since the new generation was partly an attempt to pull together all space science elements into one office, Dr. Newell's group has responsibilities for sounding rockets and the Scout, Galileo, and the Gemini launch vehicles. It does not have responsibility over the USAF-developed Thor, Agena, and Atlas Agenas, although it uses these vehicles. The budget requests included \$97 million for the NASA vehicles, the bulk of which is for Gemini.

Lunar, Planetary Work

NASA's lunar and planetary work is carried out chiefly by the Jet Propulsion Laboratory at Pasadena, Calif., and most of the scientific satellite work falls to the Goddard Space Flight Center at Greenbelt, Md. A number of sounding rocket shots and growing flights for its satellite hardware that will later be flown in orbit are conducted at NASA's Wallops Station, Wallops Island, Va.

The space science office also oversees basic research performed by NASA in universities, industry, and non-profit firms and, since it is the focal point for the exploration end of NASA's business, has by far the most contact with scientists from other countries who participate in the space agency's international programs.

Research programs dealing with life in space, other than that of man has been placed in the space sciences office, which Acropace Medicine is under the Office of Manned Space Flight and technology is a part of the Office of Advanced Research and Technology. The sciences office also has responsibility for the recently reorganized Pacific Launch Operations Office at the Pacific Missile Range, since most of the NASA launches from there will be of scientific payload and satellites.

Scientific space exploration passed a milestone with the recent launching of the first Orbiting Solar Observatory. Although this was a medium-sized satellite recognized with the large Orbiting Astronomical Observations now being

built, its complex plans fit in what Dr. Newell calls the advanced satellite category.

These observations will serve as "directors" that can carry a large number and great variety of experiments at one time. Even perhaps more important, this will permit important astronomical observations from above the earth's atmosphere, which Dr. Hans J. Coma director of Goddard, has placed in "a two-pronged blade."

Dr. Newell recently told Congress that development of the necessary instrumentation and techniques for making observations in the ultraviolet portion of sunlight which is not visible from ground observation is "a major scientific objective of the present (or near-term) program."

Because ultraviolet radiation is absorbed by the atmosphere and the



NIRE CALUM launch vehicle, NASA, Japanese atmosphere probes from Wallops Island, Va.

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techniques involved are themselves on the forefront of science and technology, this program is one in which results are measured in more than the expected. "New and

about the same could be said about any primary area of space science exploration. NASA plans to launch 11 scientific satellites, 1 scientific probe and 58 sounding rockets in this calendar year, and Dr. Newell has said in effect that it takes about one year to engineer, reference satellite data and more years to make real sense of it.

Researchers still are digging back into rocket and satellite data gathered during the IGY in 1957-1958 as new data seem to affirm or contradict earlier findings. And Edgar M. Corbridge, Newell's deputy, told Congress that in its right legs IBM 7090 computers are at work reducing information returned from satellites—a step that precedes and is much shorter than analysis of the data.

NASA's goal in the space science area is to achieve a major understanding of the universe, organized with words or analysis now, and eventually to keep several basic types of observations as well as at one time. The problems that will pose for the great number of researchers in NASA, the universities and industry who must interpret and try to understand the vast amount of information that will be gathered is illustrated well by Dr. Newell's summary of what satellites revealed in 1961.

The important scientific discoveries that the 1961 findings revealed or showed were only as good as 70-80 and more were as new as 1960 as current technology of the process of collecting, storing and understanding, even for the world of science.

The more recent observations showed the nucleus of the electron in the outer (radiation) belt appeared to be a filament-like layer with outer extensions indicated," Dr. Newell said. These observations also indicated that "about as many medium energy protons as the [magnetospheric] field can hold

were found in the outer belt; but the ultimate source of many of the protons appears to be solar proton storms as though the source is again . . . The earth's magnetic field appears compressed on the side toward the sun and blown out on the other side.

"If the field is distorted in such fashion, the presumption is that a strong solar wind is the cause. On the other hand, there have been a few observations of such a solar wind . . . Finally, although the existence of a ring current around the earth appears established, the various measurements do agree as to where this current is actually located.

"The various observations and analyses of the past year have combined to indicate that the radiation belt is the Van Allen belt now as apparently less than had been thought earlier, while the band due to energetic solar proton streams can be considerably greater.

"Considerable progress has been made in the area during 1961 but a continuing revelation of the complexity of the problem and of the need for much more detailed observation such as can be obtained with a sounding type satellite.

"Although fundamental knowledge and basic understanding are the primary goals of the space science program, practicalities have necessitated a concentration of some program particularly in the basic area. As part of the Apollo manned lunar landing program has left the Ranger lunar spacecraft program relatively unaffected but its manned Surveyor experiments further along the spectrum toward applied research—measurement of the lunar surface in preparation for man's landing there instead of a general mapping mission, for example.

The lunar and planetary programs also have suffered from unexpected delays in the development of the power systems involved in the Surveyor.

Despite these problems, the space science program remains the specified

AEROSOL now used with one Hughes Corp. and three Goddard experiments are carried by Sikorski HO4 helicopter after launch from Wallops Island to test the Aerosol sounding system.



at NASA's efforts. Its complexity is illustrated by Newell's analogy of the difficulty of achieving a guiding accuracy of 0.1 arc or arc for the Orbiting Astronomical Observatory—about equivalent to the accuracy required to use a telescope located in Delaware to pick out either the right or left eye of an individual in Washington (40 mi. away) for detailed study as to its color and brightness. But its importance and its promise are in stark contrast even greater than that of the manned flight program because it is the exploration work that must precede man to the moon and to the planets.

JPL Selects Discipline-Type Organization

NASA's contract laboratory structured along systems lines; procurement policies differ from government.

Princeton, Calif.—Principal missions of the Jet Propulsion Laboratory—research and execution of announced U.S. lunar and planetary exploration programs—are carried out with an organization grouped into technical disciplines.

JPL has selected a discipline type of organization, rather than a project-oriented one because it believes it can maximize its long-term contributions to the space effort by developing a wide range of technologies.

These qualify it to conduct and direct space work from a total systems viewpoint, possibly with fewer people and spending farther than they otherwise might.

JPL has eight technical divisions corresponding to relevant space disciplines such as propulsion, guidance and control and telecommunications—each responsible for maintaining and advancing the laboratory's competence in these respective areas. Every division conducts its own supporting research, advanced development, field activity and contractual work. Seven are organized as divisions, the eighth, the Physical Sciences Division, is devoted exclusively to research in insurance that all important fields are covered.

Lunar, Planetary Programs

Occasionally, the lunar and planetary program offices are set apart from the division but draw heavily on their talents. Division charts and program managers alike report directly to the laboratory director, Dr. W. H. Pickering.

The discipline type of organization raises some managerial problems for program offices in that they do not have direct control over divisional activities. Program and project managers must exercise more diplomacy in encouraging cooperation of divisional people over whom they have no managerial responsibility. But that independence has resulted in good cooperation with division chiefs and better talent in the divisions and has permitted a balance to be maintained among disciplines.

JPL has a somewhat different relation to the National Aeronautics and Space Administration than NASA's own centers because it is a contractor. The laboratory, facilities and 146 acres on which they stand are owned by the government. Caltech Institute of Technology, JPL's parent organization, is under contract to NASA to conduct assigned scientific and technical missions and to operate and maintain the facilities.

A JPL board of directors, consisting of Caltech faculty members and in-

cludes the board of trustees, governs the laboratory.

The contract, originally written in 1958 when NASA was formed and JPL was transferred from Army jurisdiction, has annual increments of funds. Each year the laboratory prepares a budget estimate of funds needed to conduct its efforts, returns it to NASA headquarters which studies and adjusts it, and incorporates it into the overall budget for submission to the Congress.

Procurement Practices

The laboratory's contractual status is reflected partially in its procurement practices, which are not identical with government procedures but follow them in spirit and intent, according to V. C. Lancia, Jr., assistant director for business administration.

JPL does not subscribe its procurement, for example, to the government agencies. It does, however, encourage competition for procurement, attempting to maintain equal responsibility among bidders and allowing no reluctance to give contracts to anyone needed to bid. Lancia says. Bidders' bids are a composite of prices submitted by government people and contractor companies.

The procurement office will receive contractor information with the laboratory and arrange for them to make technical presentations to the cognate laboratories, if necessary. It also accepts unsolicited proposals and directs them to the appropriate laboratory or section. Each division is now capable of creating any type of contract with industry.

In the past year approximately 75% of JPL's total budget money was placed with industry, covering the spectrum from exotic studies to pencils. This will rise to 86% in Fiscal 1968.

Industry Relationship

Decision whether a procurement project or major part of it, such as its mission package, will be contracted with industry is strongly influenced by the likely number of spacecraft to be used, which is in turn a reflection of the launch opportunities. Lunar launch op-

portunities occur more frequently—and month-day planetary opportunities and make possible more shots in a given project over a period of time. It is these high density programs such as the Surveyor lunar spacecraft for which the laboratory will avoid a complete system manager contract with industry.

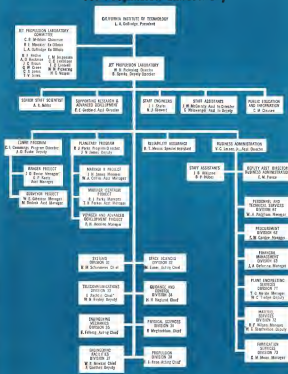
A low density planetary project, such as Mariner, with launch opportunities spaced at 18-month intervals for Mars and about 25 months for Mars, are kept in house. Mariner is kept in-house for another reason—to permit the laboratory to develop its skills in more difficult projects and remain in the forefront of space technology.

Range lunar spacecraft is an exception to the high-density rule of thumb. Like Mariner, it was kept in-house—although mission packages, or payloads for 7 of 9 shots are awarded by industry—to gain experience and develop technologies such as long-range attitude stabilization, long-distance communications, mid-course maneuvers, command, etc.

JPL's first 65 ft disk at Pioneer 10.



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ref. [Bianchi et al., 2010](#)

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JPL Requests

Pasadena, Calif.—Jet Propulsion Laboratory has requested a \$49.7 million spending budget for Fiscal 1983, and an increase of 418 employees to bring the total to 1,746. The laboratory is situated on three sites: 140 acres here, near the California Institute of Technology; 600 acres at Edwards, Calif., and a 30-sq. mile site at Goldstone Institute facility.

Current plant value of JPL is \$40.4 million. The laboratory has requested \$18.4 million for FY 1963 expenses.

Specialist projects are handled within a team or planetary program office. The program managers for the two, respectively, are Clifford E. Cummings and Robert J. Parks. Each has staff supporting staffs making up schedules and program analysis, handling fiscal and administrative matters, program planning, advanced development and test, in the home office, managed flight, launch.

Program effects have at least two aspects—Range and Service in the bear effort and Manure (*Allos Agnus*). Marine (*Centaur*) and Voyager in the planetarium office.

Authority of the laboratory director, including allocation of and access ability for funds, has been delegated to the program managers and, in the horse program, to project managers—W. E. Giberson for Survivor and James D. Baskie for Ranger.

For Severest, the project office acts as a nucleus, coordinating and supervising the work of the project engineers and two technical divisions and the mechanical management of the various engineering contracts with Hughes Aircraft Co. Highly-qualified project engineers are assigned to the Sanoyev project office from the divisions, which receive technical assignments from the project office but report to their respective division chiefs. These engineers provide liaison among the divisions, project office and contractors, take special assignments and enable divisions to benefit from the Hughes Service experience.

As well as IFL sponsored programs, the Marshall Space Flight Center has responsibility for the launch vehicle, coordinated with the project office. Also reporting to the project manager are responsible engineers within the divisions for IFL's Space Flight Operations Center, Deep Space Instrumentation Facility and Spacecraft Stations Office. Sweep-up contract is let from the project office. In the case of Ranger, in total, project responsibility remains with NASA, the instrument payload is provided by the contractor, Radio Corp. of America, in respect to a IFL specialist staff support on the Ranger contract staff.

Hydro-Space News




"Yogi Bear" Bailed Out

A short time ago, a B-54b bear—destined for immortality in aviation annals—found himself hurtling through the stratosphere at 10,000 mph after having been ejected inside a capsule from a B-48 bomber. Minutes later, he and the capsule had floated the nine miles to earth—preserved, protected and intact—a convincing demonstration of the escape system's efficiency.

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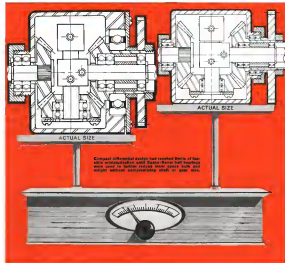
Designers can now further reduce the bulk and weight of miniature mechanisms . . . thanks to the N/D Space-Saver ball bearing series! This new torque-tube ball bearing line from New Departure is particularly well suited to mechanisms having many shafts clustered in close proximity. It can, also, help solve concentric shaft problems in limited inner space.

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If you're looking for important space and weight savings, phone the N/D Sales Engineer in your area. His varied experience in miniature and instrument bearing applications can help you. Or contact New Departure, Division of General Motors Corporation, Bristol, Connecticut.

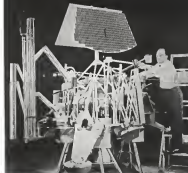


See how N/D's Space-Saver ball bearing line from N/D's miniature and instrument bearing facilities, designed into either end.



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FULL-SCALE Surveyor spacecraft model at Hughes plant. Project is directed by JPL.

veyor systems contractor, Hughes Aircraft, have been using extensive testing of prototypes of the spacecraft, which continues close to schedule.

JPL cannot control the possibility of achieving a soft lander landing with alternate launch vehicles, concluding that soft lander landing with an Apollo-Agena B was technologically feasible but impractical. Projected weight of the lunar spacecraft would be only 750 lb., most of the weight consumed by spacecraft propulsion.

Additional Reasons

More Range may be added to maximize the lunar data that can be gathered during an extended lunar mission. The current Ranger series and full-scale Surveyor launches. Both Astronautics and other firms have suggested additional components, employing the irreversible Ranger hard landing capsule and instruments or substituting new payloads on the Ranger bus.

Original objectives of the unmanned lunar program in order of importance were to:

- Better understand the origin of the moon and the solar system.
- Obtain scientific data and technological information for further lunar exploration.
- Provide a summary of information to the manned space flight program.

When these objectives were formulated, manned lunar exploration appeared 10 years off. As the Apollo program emerged to question the past, however, the order of importance of

the unmanned program's objectives became reversed.

This has caused a re-evaluation of the very project—particularly Surveyor—now viewed, but not changed in the self-imposed vehicle itself. The new emphasis probably will reshape the sequence in which the many instruments being developed for the program (AW July 1, 1961, p. 42) will be flown, giving priority to those whose measurements may benefit subsequent Apollo designs. This means greater stress on measurements of physical properties and pictures of the terrain, less on chemical and geophysical studies.

Particularly, JPL hopes to learn about lunar surface characteristics—surface bearing strength, lunar radiation environment and answers to questions such as whether there are boulders, craters or craters, what happens to lunar dust and whether our ideas of lunar temperature and surface features are correct.

Four technical concerns on the Surveyor should give a good idea of what features and features in the vicinity of the landing spot.

A set of experiments, being developed by Teneco Experiment, studied as a 10-in. probe and inserted into a hole dug by the Surveyor's drill, with a partly duplicating act on the surface, may be of greatest value. These experiments are to measure density, hardness, temperature, thermal diffusivity, porosity, compressibility, electrical conductivity and speed of propagation. If the drill fails to penetrate the lunar crust, the pro-



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Lunar Spacecraft Costs

NASA estimates that its Ranger moon lander lunar spacecraft will cost about \$7.5 million each. Soft-landed Surveyor vehicles are now being built and \$10 million each, including launch vehicle and related costs, more than double as previously in the Surveyor cost to beyond \$25 million per launch.

Surveyor spacecraft is a soft-landed vehicle expected to cost between \$10 and \$20 million, according to an estimate made by Edgar Cost right, deputy director of NASA's Office of Space Services, before Congress.

Five Surveyor B dual-lunar vehicles, using a modified Surveyor spacecraft, will cost about \$12 million, including the costs of spacecraft development, launch vehicle, release and installation support. Copyright retained.

nally duplicate set of instruments often a fallback set of readings. Should both sets operate and return data successfully, a comparison of surface and subsurface measurements will be possible.

The shift of interest to support the manned lunar effort is nowhere more apparent than in the area of field and particle measurements in both the Surveyor and Mariner projects. The interdisciplinary modern probes based to many, and proton energies between 30 million electron volts (mev) and 300 mev are the area of particular potential interest and of particular concern in support of the Apollo effort. The energy region above and below this range, however, are of some interest to cosmic ray energy measurements as well as an indication of solar phenomena, solar flares and possible existence and properties of a solar wind, while the higher energy levels might yield a better understanding of cosmic rays. Accelerated radiation environments also cause more importance now.

JPL, also is looking more closely at extending the portion of the moon that its spacecraft will view toward regions more likely to be of interest in Apollo. The western half of the moon generally is the target area for navigation shots because of lower range requirements. For return reasons, the requirements are less lenient from the eastern portion of the moon. Stationing of the unmanned program is shifting outward, with Ranger 6 through 9 intended to impact near the equator, toward the center of the disk.

Lunar orbiter data eventually will be a number of functions besides the gathering of photographic data—with evaluation perhaps from 100 to 1 meter-to-200 m in landing site selection. These would include conducting radiation and other physical experiments, determining lunar gravity and mass distribution.

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Venus First Target in Planetary Series

JPL pushes Mariner 1 for basic scientific exploration; second-generation payloads to eject landing capsules.

Producers, Calif.—Jet Propulsion Laboratory's planetary and interplanetary program has recently escaped the restrictions required in its basic program by a change in national goals, but the failure of the Crocker branch vehicle to be ready on time has cut its shadow over the timetable for exploring the planets.

Two attempts to launch spacecraft into Venus fly-by trajectories, scheduled for this summer, were scuttled down and shifted to the lower thrust Atlas Agena B vehicle because of Crocker development delays (AW Oct. 2, p. 26), and two more lightweight Mariner spacecraft may have to be substituted into the program at one of the next planetary opportunities two years from now.

The feasibility of JPL's basic and secondary approach to spacecraft construction (see p. 156) permitted the site of a basic program long for construction, with about one year's lead time, of the special planetary payloads Mariner 1 and 2 (previously called Mariner B) as substitutes for the heavier Mariner A Venuses fly-by spacecraft.

Since a Venus opportunity—the best period when the earth and Venus will be approaching their closest proximity so a spacecraft launched from earth could encounter the planet by touching a minimum distance—occurs only at 16-month intervals, NASA and JPL were reluctant to take the opportunity this summer.

Unaided by the latest beyond-shielded Ranger but with extensive modifications to increase spacecraft propulsion, after construction and add scientific instruments, JPL engineered a hybrid craft using parts of the ideas and equipment from the discarded Mariner A. The change over thus halved the 1,100-lb anticipated launch weight of Mariner A (AW Feb. 5, p. 57).

Lightweight Instrument Pack

The lightweight Mariner was to be equipped with 40 to 50 lb of instruments, including microwave and infrared radiometers, to allow temperature measurements through the planet's atmosphere, thereby displaying a temperature distribution, a temperature for measuring the strength of interplanetary and Venusian magnetic fields, plasma probes for gaging interplanetary plasma levels, an ionization chamber and Geiger counter package for measuring proton and electron, and cosmic dust detectors.

The planet's rotation rate and inclination of its spin axis, critically important parameters in planning for possible Venusian entry capsules to be ejected from follow-on Mariner B and Voyager spacecraft, may be derived from the microwave measurements

that about the planet's atmosphere contained may be obtained from radiometer readings of carbon dioxide and water vapor levels.

Mars and Venus are of immediate interest in the Mariner project because of their relative proximity to earth. The changing, periodic seasonal nature of the Martian surface and its internal structure, apparent in these measurements, are characteristic of tidal forces such as action on earth, and raise the possibility that life may exist there.

Conflicting Theories

Venus, shrouded by a heavy cloud cover, is a greater mystery which has provided many conflicting theories and conjectures. Why, for example, is the Venusian temperature as high as many

independent radiometric, spectroscopic and other measurements now agree that it is?

One theory suggests that the clouds are causing a "greenhouse" effect. Another says the high temperature is due to frictional heating caused by strong Archon winds presumed to be sweeping the planet's surface. Still another construction, contradicted by radio data, is that the absence of a strong magnetic field permits sufficient electron density so that the high temperatures are actually ionospheric and surface temperature. Why the surface is so hot, if it is, may be deduced from measurements of the planet's ionospheric distribution, which the first Mariner then was said to provide.

The planetary program faces a number of problems including the lower level program group, data at the planets that are available, compared with the more. Rather have demands are placed on communications and guidance systems must be about 10 times greater than a long-range radio transmission.

Yet critical unannounced loadings on the planets are essential to further planetary exploration, according to R. L. Park, planetary program director.

The next round of planetary probes, using Mariner B spacecraft, will have this planetary landing capability. The spacecraft itself will be intended to fly past Mars and Venus but will be able



RELATIVE positions of earth, Venus and Mars on shows for 1962 transfer orbits.

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to eject a small capsule into the planetary atmosphere.

The basic Manner B box will be hexagonal in shape, with a single structure folding out from each of its six sides. The foldouts are four solar panels, a high-gain antenna and a planetary horizon platform—FHP—carrying planetary-oriented instruments such as a horizon scanner, infrared spectrometer and TV camera. A single capsule will fit in a package.

One interesting aspect of Manner B is that it is designed with dual planet capabilities—Mars and Venus—even though there are factors which might make an optimized Mars vehicle different from an optimized Venus vehicle. For example, the solar constant at Venus is about five times that of Mars. Clearly, this means that an equivalent Mars solar panel will convert twice the energy of Venus that it would at earth, only about 40% at Mars. Communications distances from Mars to earth are greater than from Venus to earth at direct geometry, requiring more spacecraft communications power, tightening of bandwidth or greater redundancy at the receiving site, or a combination of these. The hexagonal design minimizes the effect of the difference in solar constant.

The Manner B box consists of the basic hexagonal structure, guidance and control system, communications, telemetry, power system solar panels and batteries, high gain and omni-directional antennas and the FHP.

Two capsule types are under study. One would be released early in planetary fly-by orbit as an additional velocity increment, while the other would contain a small rocket motor to impart additional velocity to the capsule.

Capsule Landing Problems

Many problems are associated with successfully landing a capsule on either Mars or Venus. Some are caused by the lack of knowledge about the planets and their atmosphere. Many others are expected to be easier because its atmospheric structure is simpler, permitting the entry vehicle to be decelerated less abruptly. The Venus atmosphere is thick and contains a lot of clouds, particularly the carbon dioxide content, are undergoing changes. High accuracy velocities and questions about blast body heat intensify in view of the possible compositions at Venus make entry into the planet appear particularly complex.

Investigations of entry capsules containing no active elements for stabilization and weighing 500 lb and less were conducted for JPL by the Ames Research Center, JPL also has had two studies conducted by General Electric Co.

The first, let through the Eng-

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meeting Mechanics Division, centered on the feasibility of using a Discoverer type body, the New (Nuclear-Electric) Recovery Vehicle capsule (ANW Sept. 26, 1960), p. 260 in a Mars entry vehicle. The Martian entry situation probably can be simulated, using a Discoverer capsule on earth entry. This would be based on an expected Mars atmospheric structure and would use self-heating of the capsule and a slightly altered angle of entry.

General Electric's second study, an overall look at Venus entry, is being done by the Systems Division.

Other problems, such as whether the capsule needs to fly in position, how to communicate with observation and what experiments should be conducted are also under study. Data obtained in an experimental capsule might be a level to earth via the Mariner B spacecraft as it flies past the planet after spotting its capsule. If the capsule were expected to survive impact and make measurements on the planet's surface, it is expected that it could still orbit via the another craft for up to 24 hr. Relay might make the communication task of the battery-powered capsule easier.

Several groups of instruments are in various stages of study and development for Mars entry because of the long lead time required. Instruments for Venusian entry also are undergoing analysis.

Instruments for making measurements both during descent through the planetary atmosphere and on the planet's surface are under investigation. Once it is feasible to expect survival of the capsule after impact, instruments for making surface measurements could be added, either might be used both during descent and on the surface.

Different type outcrops include:

single 1-to-10-db devices, each capable of measuring a single gas such as nitrogen, oxygen, carbon or carbon dioxide or water vapor. These are being developed by the Space Sciences Division. Two companies, Beckman Instruments and Nippon, have contracts to conduct studies of a gas chromatograph for determining atmospheric composition during a Marsian descent of up to 20-min duration. A mass spectrometer also is under study.

Another series of possible experiments—essentially biological devices to search for life forms on Mars—will be intended for Mariner B capsule landing—were either under study or in development, some with industry under contracts from JPL and NASA.

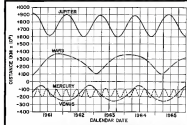
Contracts for instruments in feasibility or breadboard stage generally are let either from headquarters or the center, according to Mission Manager, chief of the Space Sciences Division. Once they advance to prototype stage and beyond to flight hardware, contracts are awarded directly by the center responsible for the mission.

Plasma surface instrument attempts to determine whether life is present, and in some cases more detail about it, by four broad categories of experiments:

- Growth experiments to see whether a sample grows or multiplies.
- Biochemistry experiments to find common and determine whether a life form is certain chemical constituents.
- Microscopic investigations to see whether the life form moves, changes form, etc.—an attempt to determine whether life is there in its appearance.
- Study of the environment to try to infer whether conditions, such as the presence of water, would permit life to survive.

Specific devices in development are:

- Multitube—Automatic Biochemical



GRAPH SHOWS planetary surface cycle relative to earth, plotting distance from earth.

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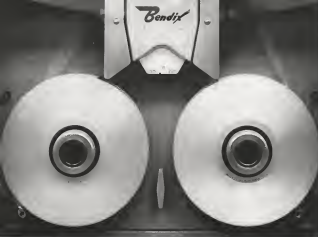


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MARKER 1 being assembled at JPL.

laboratory, devised by Dr. Jerrold Leibel of Stanford University, is capable of picking up and analyzing air samples. A small chromatography separates the sample into 18 or 23 cells for separate, and in some instances, duplicate measurements. The laboratory might perform a growth experiment by adding a surface sample to a nutrient to see whether the growth rate changes. A cell death experiment also is considered. Results of the laboratory analysis would be detected optically and teleported back to the Marker B or directly to earth.

• **Microscope**—Unconventional microscope in which samples are separated, placed on a small conveyor, then viewed under a small-diameter, high-magnification microscope. The microscope views would be picked up by TV camera, processed and returned by telemetry.

• **Wall map**—In this possible experiment, named for designer Wall Vukobratovic of the University of Rochester, the device acts as air sampler and places them in a prepared nutrient. Growth in the organism is detected by cloudiness or turbidity in the original medium. This experiment, unlike the two foregoing, is funded through NASA headquarters.

• **Growth experiment**—Samples would be brought into this device by drawing a string across the Marker surface and placing it in a nutrient touched with inductive carbon 14. If the micro-organism grows and multiplies, radioactive carbon dioxide, which can be detected, might be produced by reaction. While there is a chance that this experiment might not work, the nutrient will either support the organism or it will die and carbon dioxide is not a product, it is expended as a permanent experiment. Samples would be brought

into the device by a tethered payload which carries a sticky string about 100 ft. The device, about the size of a post box and weighing less than 2 lb., was devised by Gail Levin of Massachusetts Research, Inc. (AW May 23, p. 18).

A variety of exotic pick-up devices, including a specimen of "tissue breaker"—strings with sticky substances for picking up samples as well as electrostatic pick-ups and vacuum pick-ups are under study. Selective monitoring stations, which might pass the data that has to be returned and ease the communications burden, are also under study. Unlike the planets, the search for life on the moon is indirect, restricted to a gas chromatographic experiment which tests pre-biotic, and living, materials.

Venus Experiments

The Space Science Division is beginning to tackle instrumentation problems that would be encountered in Venus, where surface temperatures are estimated to be over 500° F. The laboratory will study the design of video cameras which could survive and operate in a blunt furnace environment, as representative of Venusian conditions.

The division has a contract with Electro-Optical Systems for making microcameras capable of operating in planetary environments. The company is constructing hybrid microcameras using silicon as a substrate and heat for active elements and a deposited overlay of titanium and titanium oxide film for passive elements.

Operation at temperatures up to 550° F is possible with these devices because of an experimental fabrication method. If the estimated temperature for Venus is correct, the planet's temperature is roughly twice the maximum rated temperature of conventional high-quality semiconductor devices.

Other areas of study and advanced development in adaptation of planetary exploration include new types of antennas and a study of new video data processing concepts to be demonstrated and display of recovered data. In general many instruments developed for lunar exploration, with the exception of an X-ray spectrometer that needs a vacuum as suitable at the moon, are applicable to planetary exploration. Some techniques such as wet chemical analysis, which have been rejected for lunar exploration, may be valid on the planets, according to Koser.

Ultimately, when the future of the Voyager project—particularly the launching vehicle—is settled, many of these techniques and developments will be delivered to flight hardware. Voyager is expected to be capable not only of going to the outer planets but of going into tight orbits about them, capturing large samples, and possibly follow-

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Mercury—More than a third of the spacecraft's analog indicators were supplied by Weston for measurement of 14 variables: fuel, coolant and oxygen supply, cabin and suit environment, A/C and D/G functions.

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ing an explosion sequence similar to that of the lunar program.

Backing up the measured lunar and planetary efforts and the Deep Space Instrumentation Facility network, also operated by JPL for NASA, is a vast, laboratory-scale supporting network and advanced development effort absorbing 40% of the entire budget and a like amount of the activities of a large personnel, according to Frank E. Colwell, who heads these support activities.

Presently all basic research efforts are kept in-house. Much of the advanced development work is subcontracted to industry. These activities cut across disciplinary lines, with such engineering divisions conducting different types of research related to its disciplines. Apart from there is a Physical Sciences Division which conducts research under an overall budget executive to mid-level budgetary cuts in specific programs or other topical problems such as biosciences available. This division is responsible for 30% of the laboratory's personnel engaged in research—50 to 60 individuals out of more than 190—and about 25% of the research funds.

There are 15 separate research areas, including physics, plantology, telemedicine and telemetry, plasma and ion production, polymer research, solid theory and relativity, nuclear physics, molecular structure, spectroscopy, dynamics, digital communications, fitting and detection theory and space-borne computers.

Research in five major fundamental, aimed at understanding phenomena such as the plasma state and predicting its interaction with magnetic fields, and directed research, aimed at advancing technology. An example of the latter would be an ion propulsion effect directed toward Mars. Some directed research is subcontracted to industry, as was done recently when Physical Sciences Division and Graduate and General Division jointly let a contract to develop space-conditioning films.

About 50% of research in the engineering division is related to improve technology and 50% is directed by basic research in the Physical Sciences Division. The personnel are recruited, according to J. Mogilovich, division chief.

In addition to its own research and development, JPL has other research facilities in the area. The Population Division, for example, acts as technical manager for about 40 "Advanced Technology Contracts," short-duration contracts of less than 18 months and less than one year, placed with industry by NASA biologists. The division helps headquarters select suitable areas for investigation and helps prepare proposals and make the contractor efforts.

Deep Space Tracking Network Expanding

Pasadena, Calif.—Radio tracking, command, telemetry and data acquisition for manned lunar and planetary probes are expanding almost continual expansion and modernization of the Deep Space Instrumentation Facility (DSIF) managed and operated by Jet Propulsion Laboratory's Telecommunications Division.

By 1967 there will be about 10 or 12 lunar and planetary shots in a year, compared with three planetary and three lunar shots in October 1962. The number of shots tells only part of the story. Command, telemetry and data handling requirements will increase sharply for more complicated lunar tasks such as Surveyor-with many of its experiments requiring real-time command—and Mariner III, which will require a high level of communication system performance.

In the near future, DSIF will have six stations—three located at Goldstone, near Barrow, Calif., in the Mojave Desert. By June of next year, when DSIF has been converted to a higher frequency—1250 to 2300 mc, the portion of JPL now covered by more than 100 antennas and communication and has subject to cosmic noise than the new low-noise capabilities will increase further.

The original Goldstone site, from which DSIF had its beginning, once a greatly improved from the original station which began operation by tracking Pioneer 3 in late 1955. The Pioneer site had a system temperature of approximately 1500K, whose system temperature, a measure of the performance of the system, is defined as 290 times the difference between noise figure and noise. New low-noise tracking system, being developed by the Microwave Electronics Corp., is expected to give that site a system noise power of 30 db, or improvement by a factor of 10, achieved in several steps in less than two years.

By this fall, when its so-called Venus station goes into operation in a research and development basis, DSIF will consist of:

- **Womans, Antenna-Mounted** and operated by the JPL S. Generalist by Antennas. Consists of a receiving station using an 85-ft. polar mounted parabolic antenna (40 db gain to the equator).
- **Johnsantown, S A—**Located 40 mi south of Johannesburg in a valley protected from man-made RF noise. Transmits and receives and employs the 85-ft. polar mounted dish of all three major sites. Staffed and operated by the Council of Industrial Research with one American, a JPL/NASA representative.
- **Transportable station—Small, transportable transmitter and 10-ft. dish used in the early portion of low altitude in orbit, up to the point of about 10,000 mi where the spacecraft is in contact with JPL in Pasadena, to which command signals are sent.**

feed stations (Womans, Johannesburg and Goldstone).

• **Goldstone—Goldstone equipment will include the original 15-ft. polar mounted antenna with highly sensitive receiving system. A second site, 7 mi to the south of Goldstone, will participate in the Echo satellite relay experiment with Bell Telephone Laboratories in Holmdel, N. J., presently has a 10-ft. horn antenna and a receiver installed after the Echo experiment ends in 1964. It will have an 85-ft. polar mounted antenna and its original 15-ft. antenna-electric mounted antenna is being moved to the third site. The latter, called the Venus site, will be a high-power, at least 100 kw—transmitting station, in tested to be in full operation for a 1964 Mariner B Venus shot. It will supply commands overcoming loss of command if a backup antenna on Mariner B is not used properly. The modified Echo site will help observe the trajectory toward station of DSIF when frequency of shots increases.**

Plans were included in the Fiscal 1964 budget request for another system—20 db gain, which would use state work on a fourth Goldstone site. This system, equipped with an 85 ft. dish has others in use in DSIF and combined with a sensitive receiver comparable to the one at the Pioneer site, will provide a 6 to 12 db improvement in signal to noise ratio. System temperature goal is about 21K.

In an unusual equipment last year, the Echo transmitter directed signals to the planet Venus, signals which were reflected from the planet and picked up by the Pioneer site receiver. Results indicated what is believed to be a highly accurate determination of the distance of Venus, a better approximation of the solar orbit around the planet and deduction about rotation rate of the planet.

Data from DSIF systems are transmitted by conventional teletype into the Space Flight Operations Center (SFOC) at JPL in Pasadena, to which command signals are sent.

The center will undergo considerable expansion in the next year, including a Space Flight Operations Facility (SFOP) that may be ready before the end of 1961. Womans Union will install a wide band receiver link to transmit radio, telemetry and television pictures from Goldstone.

The facility will receive and analyze telemetry, compute maneuvers, collect and reduce scientific data. It will be designed to carry out one or more tasks, such as direct and control one mission in real-time mode and support checkout on another spacecraft at JPL or Air Force Missile Range.

Initially, the facility for which a building is to be constructed with funds appropriated for it this year will use essentially the same equipment available to SFOC, including IBM 7090 computer, backed up by additional peripheral gear. It will be built on a modular basis to permit expansion.

JPL is studying a system study conducted with industry to take a look at the total system, including DSIF sites. General Electric research was selected to conduct a series of studies of the status display. Hughes Aircraft at Palmdale has the task of looking at SFOP communications—how to get data back from various DSIF stations, how to compare communications, what type of teletype should be used, how communications are best conducted within the facility, whether there should be message rates, TV display, etc.

SFOP will be handled by people who have handled past on specific flights, aided by the Space Flight Operations Section of the Science Division.

For Service, planning and coordinating space flight operations will be the responsibility of the Science Division, Hughes Aircraft. Hughes will calculate its own spacecraft commands and will supply a spacecraft data system team. JPL will handle other data collection and, usually a tracking data system group and JPL and Hughes will form a scientific data group.

DSIF ANTENNA for transportable tracking station near Johannesburg, S. A.



Goddard Role Focused on Space Sciences

Center has satellite, sounding rocket responsibility, operates tracking network for most space flights.

Greenbelt, Md.—Goddard Space Flight Center lives in the rich seam of space science that lies between the earth and its nearest neighbor.

It shares the bulk of NASA's space sciences program with the Jet Propulsion Laboratory. But by the limitations of its mission statement, Goddard works on earth-orbiting spacecraft and sounding rockets while JPL has the job of lunar and planetary exploration.

Scientists at this center, directed by Dr. Harry J. Goett, concentrate on integrating or developing 41 major satellite projects. Sounding rockets such as the Redstone space scooter for 34 projects, containing 57 air application satellites in continuous use or development.

Goddard also has responsibility for the atmospheric design, payload integration and flight test of all NASA sounding rockets.

Finally, the center scientists operate two world-wide tracking networks—Munroe and Minitrack—for tracking and data acquisition of most manned and unmanned space flights. Redundancy of much of the data from these networks is also done at Goddard.

Feedback Loop

Management of this center likes to look at the science-based capabilities of its staff as a feedback loop from science to engineering to data and back to science again.

Scientific capability is based in both theoretical work and in laboratory or analytical approaches. It can begin with studies at the nature of the universe as

a whole, as the work being done is Dr. Robert Johnson's Institute for Space Studies at New York City. That experimental group is an attempt to understand celestial and terrestrial events in the space sciences, to help bridge the gap between these disciplines and Goddard.

Of the science can be experimental work done in the Space Sciences Division, aimed at better understanding of phenomena or of atmospheres.

Engineering capability also has a parallel approach. The center uses engineers to manage contractual development in satellite and spacecraft, and other engineers or scientists the same team to design, develop and test aerospace satellites completely within the Goddard organization.

Finally, the wealth of data obtained from tests in the laboratory as well as from the basic information that helps the space scientist understand his hypotheses, or prove his assumptions.

This position of the Goddard staff data with the engineering plants of the center's work, other phases are described elsewhere.

Goddard's management of a satellite project is typified in the Orbiting Astronomical Observatory program. The second generation, "astronomical" satellites is an extremely complex structure that will be evolved to perform a variety of astronomical experiments. The major requirements, once the spacecraft is in orbit, are its stability of the platform and accuracy of pointing.

Project Staff

"In this job, we're not doing, but we're looking and we're not," said Daniel Masar, head of Goddard's Spacecraft Systems and Project Division. "Our project staff at this is a review board, looking at manpower, costs, technical staff. If we see a place where we can get some improvement, either by a backup approach or by redundancy, we report up."

First basic review on the OAO spacecraft help define the organization of Masar's management team: structure, control and guidance, power, thermal and communications. Scientists from each of these specialties, some within Goddard on the team. There also is an experiment coordinator who helps the project scientist, a tracking scientist from the Tracking and Data Acquisition Division, and a test and evaluation engineer from that division. These men are led by a project manager, his assistant and a project coordinator.

Working engineers from the project team maintain contact with Grumman Aircraft Engineering Corp., prime contractor for the spacecraft, and with subcontractors at IBM Corp., General Electric Co. and Rodham, Inc. The project scientist is in daily contact with the project leaders at Grumman, twice or three times a month, the working engineers visit Grumman.

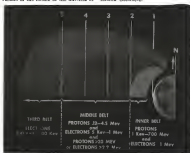
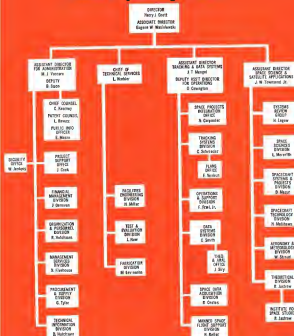
In structure, to use one example, the Goddard team reviews the Grumman work. In thermal control evaluation, they felt that there were too many uncertainties that it would be best to have a backup contract.

Similar backup contracts exist with Lockheed-Pratt, for the star tracker as which Kallman Instrument is prime, and with other companies.

The Goddard group sets environmental specifications for the OAO, using data from Vanguard and Atlas Agena vehicle vibration measurements. The contractor sets up its test plan based on that specification and performs the first tests. The prototype spacecraft fuel tests, plus its only test as a complete observatory—that is, with the experimental package installed—will be done at Goddard.

In contrast to Masar's management group, the Spacecraft Technical Divi-

Goddard Space Flight Center



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Goddard Request

Greenbelt, Md.—Goddard Space Flight Center, located about 35 mi. northwest of Washington, has requested a \$50 million spending budget for fiscal 1968, and an increase of 150 employees to bring its total to 2,749.

The center, which has a \$21.8 million construction request for the current fiscal year, is situated on a 516-acre tract that value is \$14.7 million.

Now, headed by William Matthews, represents Goddard's in-house development and fabrication group. His home group was part of the old Vanguard organization at the Naval Research Laboratory, and many of the staff have been working on these kinds of problems for 15 years.

Matthews' responsibilities include the provision of small scientific satellites. In addition, that means less than 500 lb. His group has built a total of 25 spacecraft, of which seven are now in orbit.

Airist Satellites

One of these was the UK-1 "Aurora," the first international satellite developed by a group of British scientists and Matthews' people. This and other international satellites follow a set plan. The British scientists—those from whom other countries may participate—draw the requirements and planned them, built the instruments and decided what they wanted in the line of results. Matthews' group did the basic design of the satellite itself and worked out all the rest of the spacecraft, in short, they provided the means of getting the British experiments into space, of helping them work, and of getting the data back in a useful form.

That is the plan for a first international satellite. But the second-UK-2—is now being built by a joint team of British and Washington scientists in accordance with the Goddard philosophy—first, not getting into "production" on any satellite; and second, doing as much as possible to educate and help others into the business. Project plans for UK-3 will be the same, but to be done by the British, at the Royal Air Force Establishment, Farnborough, England.

Testing Division

One of the major facilities at Goddard has been jointly referred to as the John C. New Space Flight Center, after the division head in charge of test and evaluation. Now under construction at Goddard is an experiment test and evaluation laboratory, which when it is completed, is expected to set the standard

for spacecraft checkout. Its primary value, says New, is expected to be in improving reliability.

For this reason, and because New didn't want to be in the position of leading a group of critics of design, his organization reports through a different channel to the Goddard director (see chart on p. 179).

Testing is rapidly becoming a different field from what it used to be. Now says New. There was a time when the test engineer was less concerned with the test itself and when test departments were assigned either of the most new engineers or the oldest and dullest engineers.

Test Equipment

But testing now demands test equipment that can measure at least one order of magnitude better than the toughest prototype requirement. New carries that philosophy over into his personnel, and tries to get people who are "who are order of magnitude better." Two-thirds of New's people have graduate degrees, with about half of them Ph.D.s.

This is high for any kind of engineering organization, and almost unheard-of in test work.

"Our real problem is to do the job right the first time," New points out. "We want to get into the project early, to establish the test requirements, and to set up the program."

The program generally uses three test articles: the engineering model, which is not much more than a detailed sketch; the structural model, which is complete and accurate in structure, and the prototype, which is carefully substantiated from the flight model.

The engineering model gets some testing, but the real work, both with the structural model. It gets dynamic tests to find amplification factors and the strength of the overall system. These results largely define the specifications for the substructure, according to center engineers.

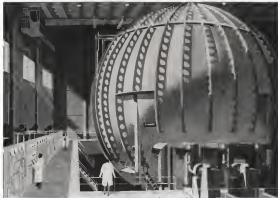
Prototype Tests

Prototype model testing is as rigorous as it is possible to make it, with the basic aim of reproducing the entire range of circumstances. Zero-gravity and radiation are not, but everything else is done: humidity, cold storage, high temperature, shock accelerations and vibrations. It is heavy tests expected to be made, open and balancing tests, and cold temperature at ambient pressure, thermal vacuum exposure.

"Our big interest is the failure mode," New emphasizes, "because that's how we can improve quality assurance. It doesn't mean we have to fight all the project team that just wants a quick fix."



ARIEL SATELLITE, UGI, developed jointly by U.S. and British scientists, is shown at lift-off Apr. 26, 1962, from Cape Canaveral's Complex 17. Launching of the first international satellite was successful, with Thor Delta used in launch vehicle. Ariel was one of several satellites launched under which NASA's Goddard center will help develop other international satellites. Goddard personnel design satellite and launch it. Participating nations select the experiments to be carried aboard satellite, plan them, and build instrumentation. UK-3 will be built by British and Washington scientists, UK-4 by British study in Farnborough.



The General Electric's Wiley Post Space Technology Center, Stokes designed and is currently installing three space environment test chambers like this one shown above in its world's largest. The chamber's 30' in diameter, will an experimentally pumped helium high-vacuum, and support over a variety of conditions and operating conditions making highly intensive tests.

EXPERIENCE IS WHAT COUNTS IN SPACE SIMULATION

While space simulation is a new and rapidly changing art, experience in designing and building equipment for its full-scale accomplishment is of the utmost importance. That is because so inaccuracies, no approximations are possible, reliability proving depends on sophisticated absolute values.

F. J. Stokes offers an extensive backlog of experience in supplying major space test facilities. The installation described above and others for General Electric, the Vacuum and cryogenic systems for facilities at NASA's Goddard Space Flight Center, the test chamber for Bell Telephone Laboratories' Tolson project, reliability testing facilities for space-borne electronic components, and pumping systems for various astronomical research centers stand as benchmarks in Stokes' progress in this specialized area.

Behind this specific activity stands half a century's experience as one of the world's leading manufacturers of high-vacuum industrial systems. Since vacuum is the common denominator of all space test equipment, it follows that Stokes' high-vacuum experience, unique engineering capabilities in this field, and extensive, long-dated information facilities can be successfully applied to problems of space simulation.

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Goddard Satellites Probe Space Sciences

Space phenomena observations opening new areas of knowledge about earth, moon and solar system.

Greenbelt, Md.—In quality and quantity, scientific satellites developed or managed by scientists of the Goddard Space Flight Center are adding immeasurably to man's knowledge of the universe he inhabits.

For the first time in scientific history, instruments can make their measurements free of the distortions of the earth's atmosphere and thus improve the quality of the measurements.

A single orbit of a typical satellite has produced more data on a single phenomenon than all man's observations from the dawn of time until its flight.

There is no hard and fast definition of a scientific satellite. All satellites produce scientific information of one kind or another, whether or not they have on-board instruments; it is instrumental. Much can be learned in a geophysical sense from tracking a known vehicle.

But at NASA, there is a rather rigid definition of a scientific satellite, and it is tied to the legislation that created the administration.

Satellite Tasks

NASA considers that scientific satellites are those that advance the space sciences program. Consequently, they investigate the basic physical phenomena that characterize the earth, the moon, the sun, the solar system or the universe and the interplanetary matter surrounding them.

Since the first exploratory forays into space, satellites have grown in size and capability. Today's sophisticated vehicles are being used to study and define a variety of things that had not for the longest time been known.

Approximately a dozen scientific satellites launched during the past few years are still in orbit, although many of them have stopped traveling. Typical of those have been the Explorer series, a number of compact specialized spacecraft aimed at a variety of targets in the vast unknown that surrounds the earth. These have been the milestones.

• **Explorer 6 results:** First complete scheduled close-cover picture was obtained, large map of electrical current swirling the earth was detected, complete map of the Van Allen radiation belt was obtained.

• **Explorer 7 results:** Significant geophysical information on pulsations and magnetic storms was obtained; internal temperature control method was demonstrated; first interplanetary penetration of a space in flight was detected; large-scale weather patterns were observed.

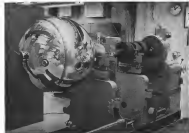
• **Explorer 8 results:** Discovery of a layer of helium surrounding the earth between the altitudes of 600 mi. and 1,500 mi.

• **Explorer 9 results:** Atmospheric density was about one-tenth that measured during the previous year at the same time, attributed to decreased solar activity during this portion of the 11-year solar cycle.

• **Explorer 10 results:** Ring of electric current around the earth was detected at about two or three earth radii, suggesting a connection with the results of Explorer 8; interplanetary magnetic fields were found to be far more intense than previously believed; terrestrial magnetic field merges with the interplanetary magnetic field about 40,000 mi. from earth.

• **Explorer 11 results:** Disproved one theory of the origin of the universe. The theory contended that matter and anti-matter were created continuously and equally.

• **Explorer 12 results:** Van Allen belt was discovered to be a single relatively more instead of two as previously believed; outer zone of the belt was found to contain large flux of electrons; gamma rays not before found in the



4-4 ATMOSPHERIC observation satellite on spin and balance test (above) and being prepared for checkout in the thermal vacuum tank.





ROOM AT THE TOP

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help, after new election, debate was assumed to be one theoretical twist less than previous sessions had indicated, attributed either to both early assessments or the decline in a solar sunspot cycle.

The part that Goddard plays in the scientific satellite program is a dual role. First, it conceives, designs, develops, builds and tests scientific satellites within its own organization. This includes, as dramatic byproducts, advances in the technology as telemetry and computers, for example, both areas in which specific and major contributions have been made by the center's personnel during their work on the projects.

Such in-house work also pays off in the second Goddard role, where it acts as a managing agency for contractor programs. The technical work done on its own satellites gives Goddard the badge of authority for measurement of outside projects, and a degree of expertise that would not be achievable without the basic facts acquired.

Goddard's organization, although young in the framework of NASA, is experienced in just the kind of scientific work. The case of the pump time from the Naval Research Laboratory, where they had specialized in an outstanding and internationally recognized program of upper-atmospheric research.

First of their projects in-house was Vanguard 3, a liquid-fueled rocket to the Navy's former Vanguard program, taken over by NASA. Much of Explorer 8 was also Goddard in-house work. Explorers 10 and 12 were all Goddard satellites. And, the first astronomical satellite, was a Goddard spacecraft with British-designed and developed upper-atmosphere aboard.

Early last month, typical work in the Goddard laboratories and shops included the first two flight units of the atmospheric stratospheric satellite (S-6) and the S-5A (follow-on) to the magnetic particle satellite Explorer 12. Flight S-6 was in final checkout, second flight was being set up components and re-assemblies installed. The S-5A was in the engineering mockup stage, with its components being carefully fitted into the spacecraft profile housing that serves to define the dimensions from the apex of the instrument.

At the same time, unique tape recorder were being built and tested. These fit into a 7-in.-dia. disk, will record for 100 min. and play back the recorded data in two minutes. Fidelity of the playback an output is less than one per cent post-pulse peak error and flutter. Power requirement for recording is 0.1 watt, and for playback is 0.7 watt. Tape is a continuous-loop type. All that is achieved at a weight of about three pounds.

The NASA budget for scientific sat-



GLAUCONIS CONTROLS CORPORATION

LOOKING FORWARD

by John Hertz

PASADENA, CALIFORNIA: To the searching mind, President Kennedy's advance on space as the "new frontier" opened new interesting similarities in the problems that face our astronauts and the problems that stung the agency of world explorers 650 years ago.

Compare, for example, the technical complexities of measuring speed. Columbus' Santa Maria and John Glenn's Freedom 7 were both subject to their own shock waves.

Columbus, however, had nearly to toss his simple chiplog and leashed line beyond the Santa Maria's bow-wave but speed and the Western principle could easily be made understood for all it concerned him.

Today, the challenge of measuring the speed of space vehicles on the basis on which such like young James B. Rochester fix their scientific noses. Rochester is concerned with hypervelocity here at the GOC Research Laboratories of Glauconis Controls Corporation, pursuing a project sponsored by the Flight Control Laboratory, A 5 D, Air Force Systems Command.

Madly but enthusiastically, Rochester explains that he and his group of experts are applying the same principles toward determining the rate of travel at space velocities, especially in the diagram "water" of matter, as did Columbus, Vasco da Gama, and Drake.

They literally are putting "markers" into the flow past a selected re-entry vehicle to measure its velocity in the same environment Columbus' dipping woe, of course, lay in the heat of friction.

Then what of Rochester's "markers" in this last border of re-entry?

"If you can't look 'em, jim' em," goss Rochester. "Get instrumentation that not only is compatible with the environment, but also employs the environment."

That's precisely what they are doing, making use of the conducting properties of the ionized gas, the plasma with its "conspicuous surface of ion and electrons" sheathing the re-entry vehicle.

"One method," Rochester explains, "is essentially introducing a 'marker' into the ionized gas, and watching the image of this marker as it moves around the vehicle."

This space-age chip log is not a mechanical thing, of course.

"We're doing this by a magnetic interaction," Rochester continues, "with the plasma itself."

"It is a pulse magnetic interaction, using an electromagnet to give to a particular magnetic configuration in the shock layer."

"As we pulse the plasma, we change its character at that point. This sets up a wave in the plasma that propagates at a particular velocity."

The velocity of this "blob" as it moves around the vehicle has a relationship to the velocity of the vehicle itself, and this in turn can lead directly to determination of angle of attack.

Of course, the velocity of the "blob" cannot be assumed to be the same as that of the vehicle itself, says Rochester in anticipating the future math of the work, "we are looking for the relationship between our velocity and the other."

Most dramatic application of such a system would be the means of the first man safely from a lunar voyage. Rochester, a native Californian and UCLA graduate, agrees.

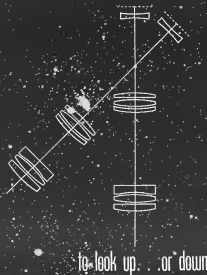
"When they are coming back, their vehicle will be in an ionized sheath for a large amount of the re-entry phase, and it won't be for only a matter of minutes like Glenn and Carpenter. It will be a matter of sliding the earth possibly once or several times."

"They will have to know their exact velocity and angle of attack to be sure that their vehicle structure will be able to take it."

Then in a quiet Pasadena laboratory, still another team is Looking Forward.

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illion during Fiscal 1961 was \$544 million. The following year it declined to \$117.6 million. The requested budget figure for Fiscal 1963 was \$175.2 million.

What has been and has brought is listed by NASA by calendar years. During 1961, seven Explorer satellites were launched. This calendar year, the schedule calls for two Explorers and two Orbiting Solar Observatories (OSO), making a total of 11 scientific satellites.

In Calendar Year 1963, NASA has scheduled three Explorers, two Orbiting Geophysical Observatories (OGO), although only one was made in 1962 and two OSO launches, for a total of seven.

For 1964, plans call for five Explorers, four OGOS, three OSOs and the first two Orbiting Astronomical Observatories (OAO) launches, totaling 14 scientific satellites.

In 1965, the NASA schedule shows one Explorer, four OGOS, four OSOs and two OAOs, a total of 19 scientific satellites. The 1964-1965 period includes the Year of the Quiet Sun, during which there will be a major effort all over the world to observe the sun and to correlate and coordinate results, somewhat in the manner of the International Geophysical Year.

Experiment Selection

The problem of selecting experiments for scientific satellites could become overwhelming were scientists in the heavens to at least one idea for an experiment to be done in space.

NASA has established the Space Sciences Steering Committee, with Dr. Eugene F. Merriam as chairman, to make the final selection of what flies in every scientific payload.

There are half a dozen subcommittees of the steering committee that make recommendations for experiments to be flown.

They are reviewed by Dr. John Clark, associate director and chief scientist of the Office of Space Sciences.

Typical of the detailed procedure involved was the choice of experiments for the OGO (Orbiting Geophysical Observatories) launch. Four subcommittees, including about 50 scientists from universities, reviewed all the experiments that had been proposed for OGO. Some of the experiments could be ruled out as unworkable, others because they were becoming obsolescent due to the constantly-gained new knowledge in space sciences.

There were some experiments that were ahead of themselves in so far as the state of technology was concerned, they would be interesting to do if they could be done. The subcommittee recommended that the ideas be developed further for possible future launches.

Finally, there were some first-class

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Can satellites cut communications costs?

Within a few decades, National Aeronautics and Space Administration plans to launch the first Hughes Space Communications satellite into orbit. Hughes engineers expect that this system can be the prototype for an advanced synchronous satellite system which could significantly reduce transoceanic communications costs.

A synchronous satellite is one which orbits the earth at an altitude of 22,360 miles. At this altitude it can be made stationary over one assigned latitude—transmitting one revolution with the earth each day.

From this position the satellite would "see" 49% of the earth's surface. And it could serve as a "switchboard" in space—relaying signals between ground stations as far as 10,000 miles apart.

The Hughes communications system would require just three such satellites spaced around the earth (see fig. 3 below). They could handle international telephone, TV, telegraph and radiophone service to every inhabited place on our globe. Equally important, the Hughes concept would simplify life with greater simplicity and economy. For example, with just

three satellites to put into orbit, fewer boost rockets would be expended—and valuable launch pad time would be saved.

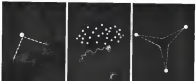
Compared to other proposals, the Hughes system would require much less expensive ground stations. And because each satellite is the Hughes system would require stations over a point on earth, each could continuously communicate with many sta-

tion stations to put into orbit, fewer boost rockets would be expended—and valuable launch pad time would be saved.

Compared to other proposals, the Hughes system would require much less expensive ground stations. And because each satellite is the Hughes system would require stations over a point on earth, each could continuously communicate with many sta-

Three concepts of satellite communications

(1) Passive reflector satellite.—NASA's Echo balloon used space signals could be "bounced" from one point on earth to another. **(2) Low altitude active satellite** would store in memory radio signals and retransmit them. **(3) Low altitude active satellite** would store in memory radio signals and retransmit them. **(4) Low altitude active satellite** would store in memory radio signals and retransmit them.



to orbit will be the Orbiting Geophysical Observatory (OGO), a series of satellites intended to perform many experiments in a wide variety of orbits, and to conduct these experiments simultaneously in both earth and sun. First of this class will be the OGO. It goes as close from the highly eccentric orbit which is planned, it successfully will orbit, it will have a 160-day perigee and a 70,000-mi apogee. Orbital inclination will be at 51 deg to the equator, and orbital period is expected to be about 95 hr.

Weight of one of the OGO series will be about 1,000 lb per observatory, regardless of type and number of experiments. OGO will be launched from Cape Canaveral using an Atlas Agena B.

Second of the OGO class is known as POGO, for Polar Orbiting Geophysical Observatory, and is intended to be launched late in 1969 into a polar orbit. For this reason, it will fly from the Pacific-Midantic-Karagee Sea basin while will be the Thor Agena B. Planned orbit will have an inclination of 90 deg to the equator, a 160-mi perigee, a 57-mi apogee, and a period of about 96 min.

These orbits are highly eccentric, one pole—represent two extremes, inter OGO class, will be launched into planned orbit with inclination, apogee heights and periods between these values.

NASA sources say that OGO development will cost \$114 million, including salaries, support, spacecraft and launch, for the development phase flight. Repeat cost would be approximately \$15 million per launch including the experimental packages.

Space Technology Laboratories is developing the OGO series for NASA.

Astronomical Satellites

Biggest and heaviest of the currently planned observatory class, the Orbiting Astronomical Observatory (OAO) is a spacecraft designed to be capable of carrying a number of astronomical instruments and of pointing them with extreme accuracy. For the first time in history, astronomers will be able to make observations of the heavens with instruments that are not obscured by the atmosphere and the dust of the earth's atmosphere.

Early planned experiments center on ultraviolet astronomy, with visible light observations coming along on later OAO spacecraft. Some indication of the kind of experiments possible is given by the dimensions of the experimental package, which is 46 in. in diameter and 14 1/2 in. long. One of the planned experiments will use an optical telescope with a 16-in. mirror.

Weight of the observatory will be about 3,300 lb, including the exper-

imental package, and it will be launched by an Atlas Agena B vehicle from Cape Canaveral. Plans call for a similar orbit in 1974.

Development cost for the OAO program for three flights is estimated at \$104 million, including salaries, support, procurement of spacecraft and launch vehicles.

Prime contractor for the spacecraft is Grumman Aircraft Engineering Corp. Principal subcontractors are General Electric Co.'s Missile and Space Vehicle Dept., for the instrumentation and control systems, and IBM Space Guidance Center, for the control center.

Future Satellites

Meanwhile, the special-purpose satellites also have a future. The philosophy seems to be two-pronged: first, develop a "standard" satellite that can carry a lot of experiments. Rough out the uses of special interest with these and then, in the second prong, develop special-purpose satellites that will in practice carry a few phenomena.

One example of the special-purpose satellite is Goddard's IMP (Interplanetary Monitoring Probe). This spacecraft is a combination of Goddard's 10 and 12, and is being designed to monitor radiation through a complete solar cycle of 11 years.

There will also be future satellites which will report experiments already conducted, or will extend their range.

Ultimately, they will develop a third-generation spacecraft which will be characterized chiefly by precision of some on-board logs. Goddard scientists say they consider the first generation of satellites those types that in effect look at everything. They continuously monitor and record data and transmit it at the end of the mission. The second generation will be able to select, and the third will be able to choose the what looks the best.

Second-generation satellites, according to the scientists, include those spacecraft that can be told to look at something special by command from the ground or by built-in programs. The selectivity of these spacecraft will be greatly improved, and the quantity of data will not be reduced to meekness, and will be considerably smaller.

Finally, the third class of the spacecraft is the discriminating satellite, the spacecraft that scans the heavens and recognizes something of interest on which to concentrate. It then swings into action and records data, rejecting everything that appears normal except for a few chance parameters. At least in some abnormality appears, the custom battery of sensing and recording instruments then record, and records an event the phenomenon has stopped and normal conditions have been reestablished.

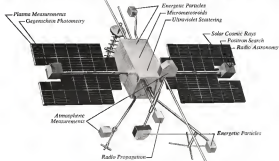
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OGO: its first mission. Scheduled in 1983, OGO (NASA's Orbiting Geophysical Observatory) will be launched into an elliptical orbit around the earth. It will gather, process and transmit data on the physics of near-earth and outer-space. Here are some of the studies OGO may undertake in this initial flight: *Energetic particles*, with nine separate experiments on the flux and characteristics of these particles (including cosmic ray and plasma studies). *Radio propagation* and *ionosphere*, through measurements of ambient radio energy not accessible from earth. *Micrometeoroids*, to determine the mass

distribution and direction of interplanetary dust in the vicinity of earth. *Magnetic fields*, their intensity, direction and variation near earth and in space. *Atmospheric measurements*, to study the pressure, temperature and composition of earth and outer-space. *Ultraviolet scattering*, from hydrogen in space. *Geophysical phenomena*, to study sunlight scattered by interplanetary matter. OGO will be launched into a wide range of orbits and may carry as many as 50 different experiments on each of its missions. The Orbiting Geophysical Observatory will be one of the most versatile earth satellites ever built.



*Capable of various possible arrangement of measurement systems which OGO may carry

OGO: its challenge. Today OGO demands advanced techniques in spacecraft design and development to meet its need for flexibility. It is a challenging responsibility to STL engineers, scientists and supporting personnel, who design it, fabricate it, integrate it, and test it. This versatile spacecraft will be manufactured at STL's vast Space Technology Center where expanding space projects (OGO, Vela Hotel and other programs) create immediate openings for engineers and scientists in fields

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Sounding Rockets Play Prime Science Role

Greenbelt, Md.—Sounding rockets, one of the specific responsibilities of the Goddard Space Flight Center, are the workhorses of the space sciences program.

Primary purpose of sounding rockets is to obtain useful atmospheric and astronomical data from altitudes unobtainable by other means. These specialized vehicles have a record of better than 99% successful operation.

Working in the region between 20 mi—upper limit for balloon-based experiments—and about 100 mi—lower limit for satellites—the rockets have been the basis for determination of all upper-atmosphere and present observations. They have photographed cloud cover, determined types and changes of solar flares, obtained the first ultraviolet solar spectra, and carried nuclear condensation into the visible region.

The entire program branches through Goddard, which is charged with the responsibility for aerodynamic design, payload integration and flight-test program.

Primary justification for sounding rockets is their ability to operate in the altitude range between 20 and 100 mi. The region, of particular interest to scientists, contains the D-layer and the lower E-layer of the atmosphere. The properties of air, controlled near the surface of the earth by mixing processes, are influenced here more by diffusive processes.

Many of the available sounding rockets have altitude capabilities much greater than 100 mi, which gives them the unique ability to give a vertical sampling of the atmosphere. The K and J regions of the ionosphere, not to be confused with the J and K regions of the ionosphere, are best probed by rockets to get a sample which is useful

in itself, and which also can be integrated to get total properties.

Altitude capabilities of some sounding rockets also makes them useful for planetary experiments. Special instrumentation needed for satellite measurements can often be built and tested at the proper altitude in a much shorter time than it would take to get it flown on a satellite. A sounding rocket payload can be built and flown in a time span of six to nine months. A satellite payload, taken time away on the order of two years.

The problems of the preparation of the payload, the launch, integration and reduction of the data are similar to those of a satellite. That similarity, the relative simplicity of the sounding rocket, its simpler operation and shorter lead times for every phase, make the sounding rocket program a relatively easy initiation to space program as a whole.

Quick reaction capability, a term usually associated with military weapons, also applies to sounding rockets. All of the types used (see box), with the exception of the Aerobee, have solid-propellant rocket motors. They can be set up and fired with a maximum of make ready time, so that measurements can be made shortly after a boring event—such as a solar flare—has been observed.

NASA Sounding Rockets

Rocket	Payload wt. (lb.)	Design alt. (mi.)	1959	1960	1961	1962
Aerobee 100	75	80	0	4	8	
Aerobee 150, 150A	150	150	4	11	8	4
Aerobee 200	30	300	0	3	2	
Argo E-5 Javelin	30	600				
Argo D-4 Javelin	30	800	1	5	8	1
Argo D-8 Javelin	100	1,300	0	1	2	
Arcon	40	55	4	2	1	1
Orion	100	180	0	2	1	1
Nike-Apache	80	150	5	10	8	
Nike-Cajon	30	150	0	24	23	12
Skylark	150	180	4			
Nike-Apache			0	0	5	

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Philosophy of Use

Basic philosophy governing the choice of a rocket as a satellite in performing an experiment is simple. It is to accomplish the experiment with a sounding rocket, don't waste a satellite. And, as a sort of corollary philosophy: use the sounding rocket for experiments that can't be done much better with a satellite.

These are typical of the experiments done by sounding rockets in the NASA program:

- Composition of the atmosphere not determined by static and in-situ measurements carried 154-160 km by an Aerbee.
- Wind shear and turbulence in the region from 58 to 123 km was determined from radar-radar trails recorded from the payloads of several Nike-Apex rockets. Experiments of this type will be performed at Cape Canaveral this year to determine the wind pattern over the Cape.
- Atmospheric composition was determined by carrying the flash of light spectroscopy carried aloft by Nike-Cajon rockets with the time that the explosion was heard.

- Cloud cover photography was done during a pair of Aerbee flights.
- Ionospheric investigations were made by an Aerbee, two of these carrying expendable payloads to obtain measurements for the influence of the ionosphere. Other measured the D-layer conductivity and the E-layer electron content.

- Solar beam experiments. Fourteen successful flights out of 34 launches characterized this program, which was done to obtain information on the types and classes of particles in solar beams produced by solar eruptions.
- Ultraviolet-spectra studies. This was measured on an Aerbee flight of 120 km altitude.
- Ultraviolet stellar spectra. Four Aerbees were fired for astronomical studies of ultraviolet radiation from stars and nebulae. In one run, out of 36 runs observed, only one of the cooler stars at about 12,000° appeared in the ultraviolet as was expected, based on knowledge of the sun. The hotter the star, the more the readings of the other runs agreed with theory. Some Goddard as-

tronomers have postulated that the different behavior might be due to spin-mechanics of helium hydride, which do not, under earth conditions, form such compounds.

- Radiation intensity. First New (Nuclear Radiation Recovery Vehicle) experiment was flown from the Pacific Missile Range on board an Agos D-8. Three broad-band gamma collimators were flown to be studied for correlation of radiation with the radiation intensity measured on the instruments.

- Earth magnetic field. The first all-India super magnetometer was flown to measure the earth magnetic field to an accuracy of better than one part in one hundred thousand.

Find Anywhere

The relative simplicity of the sounding rockets and their supporting equipment makes it easy to set them up at various sites for firing as well as during the International Geophysical Year and is still being done. Rockets are fired from NASA's Wallops Station, the Pacific Missile Range, White Sands Missile Range, Australia's Woomera Rocket Range, and Canada's Ft. Churchill.

Reentry is not usually a problem. Payloads are most often not recovered, with the exception of special shots such as the Navy firing.

Not only firing sites from the international side of the sounding rocket program. For many of the reasons cited earlier, many foreign countries have been able to gain entire into space much sooner and much more economically than if they had to wait for a satellite experiment.

Cooperative Efforts

Italy has been doing cooperative research with experiments in the range at Sorfima, using the training in a Wallops firing, for early sampling. Japan has arrangements for their sounding rocket program has been flown on a NASA-fired Nike-Cajon for comparison of techniques.

Sweden has fired Nike-Cajon rockets. A Norwegian experiment is planned at Gaddstad gaming experience to take home. India and the Argentine are talking about a similar approach. France checked ground facilities for the Columbia-Medusa range at Gaddstad.

Cooperation has joined the program, day, along with scientific and research activities.

As a result of this increased interest, plus the continued expansion for a steady, high level of sounding rocket activity, next year's flights will be a scheduled increase of about 15%. This calendar year, about 70 sounding rockets will be fired.

For the calendar year 1963, 100 are scheduled.

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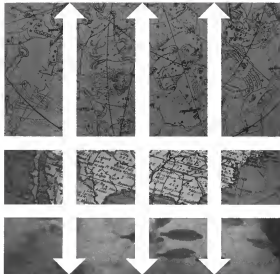
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particular project for the duration of the FY.

To handle this workload, Thompson directs a staff of 1,675 employees, the second largest number in NASA, about 8,200 of these are professional grades. Almost one-third of the professional staff specializes in aerodynamics, 20% in structural specialties, 15% work on the mechanics of flight and 13-15% on fluid mechanics.

Preeminent Work

Three types of projects dominate the aircraft and development side of Langley Research Center.

- Support of the lunar mission. Studies here are concentrating on the problems of guidance and control, of navigation of lunar approach, descent, landing and flight, and of rendezvous and docking. One fascinating aspect of the work is a series of simple, low-cost simulations using unpowered rockets to answer the problem area. These simulations involve a "tandem" approach to a landing in a narrow corridor, and a three-body rendezvous problem in which the pilot tries to align two orbiting tanks and then to dock his spacecraft to the second tank.
- Manned earth-orbiting libration. In

proposed "little boy" upgrade, military aircraft model is being wind tunnel-tested, above, at Langley Research Center. Subsonic model models are attached to wings. Below, drawing shows design of variable wing wings.



the project area, studies cover conceptual design, structural techniques, approach problems and guidance and control. One example: dynamic stability studies of a typical tandem design are being made to determine some of the parameters of response to atmospheric

- Unmanned earth-orbiting. Inflatable structures for the Echo series of passive communication satellites has been developed here. The work continues, primarily in the area of structures.
- Re-entry physics. Proper Fox, the studies of re-entry at hypersonic velocities, is a major effort at Langley both physically and theoretically. Other aspects of this work include the Tribble series of launches, some re-entry vehicle, and the development of ground test facilities for checking flight data against experience and theory.

• Aerodynamics. Biggest single effort is aimed at technical development of a supersonic transport, one of the critical missions outlined in the Langley charter. Related technology is developing

for the multi-mission fighter, featuring variable geometry wings. Aerodynamic work also includes helicopters, V-STOL, aircraft and ground-effect machines.

• Launch vehicles. Primary emphasis is on the dynamic loads of launch during the first period of the flight. Areas of the first hundred seconds. Scout and Saturn are the two vehicles under consideration for the next part. Basic investigations into such phenomena as wind shear occupy a large portion of the sponsored workload. One of the most useful test facilities is a one-fifth scale model of the Saturn which is dynamically similar to the full-scale vehicle.

Not Alone

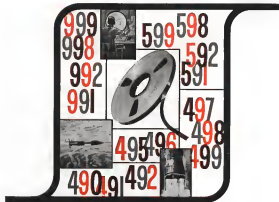
Back in the days when Langley was the last one of aerodynamic knowledge in this country—a position which the center claims it still holds—it was no resource provision, experimentation and theory that developed the craft; but rather, the scientific method, the low-drag wheel, the biodynamic wind tunnel and many other contributions to aerodynamics. But now, as the mission has changed and the tasks have become

Langley Research Center

NASA's Langley Research Center is located at Langley Station, Hampton, Va., and is divided into two main areas: Langley AFRL, headquarters of USAF's Tenth Air Command. NASA property tank 773 acres occupied, of which 192 are owned by NASA and 141 are owned under grant from the Air Force Research and some activities are owned jointly by NASA and USAF.

Current plant value of the institution is \$215,151,000. Operating cost for FY 1962, which ended June 30, was \$41,640,596. For this fiscal year, NASA asked for an increase to \$48,719,600. Construction during last fiscal year amounted to \$6,512,000, this year's is budgeted at \$1,001,000.

Langley Research Center also asked for an increase in its authorized staff from the fiscal 1962 level of 3,628 to 4,000.



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more complex, NASA has logically had to rely on groups or individuals who can do specific jobs in specific disciplines more efficiently and economically than would be possible at Langley alone.

In addition to these outside expenditures, large portions of the center's budget are devoted toward the purchase of large equipment or its construction. Project Fire, which started off at a \$1-million level in its exploratory phase, is expected to grow to a multi-million dollar contract.

This kind of money will go to the outside contractor—in this case Republic Aviation Corp.—working on the development.

Personnel Training

There is a final important task, emphasized in the mission statement, that center management takes very seriously: training people for advanced capabilities. The center encourages graduate degree training and one in four of the professional staff is currently enrolled in the center's Graduate Education Program. Apprentice training is a major part of the education program. More than 80% of the 524 technicians and designers who have completed apprentice courses here in the past 20 years are still employed in NASA.

Hypersonic Aircraft

Hampton, Va.—Studies of winged-to-robot vehicles and air-breathing boosters continue to point toward the ultimate value and possible use of both of these concepts.

Scientists here have made preliminary design and configuration studies of several concepts of these two extensions of aeromachined technology.

Major advantages of the winged-to-robot vehicle over its ballistic counterpart is that it gives occupant the ability to maneuver at will from orbit position. Conventional landing also has obvious advantages.

The real problem here exists on the landing leg air materials, the only way to improve landing times for winged-to-robot aircraft is through greatly improved materials.

The engine cycle seems to be the toughest problem in the air-breathing boost. There is more belief now that a turbofan is a good starting point, to be followed by an engine cycle and liquid-fueled cycle, and then by burning the oxygen with liquid hydrogen.

One NASA engineer said that current studies show a winged-to-robot aircraft is probably out of the running. Another engineer said that about half of Langley's future aeromachined research will be on the air-breathing booster designs.



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Langley Explores Manned Space Station

Hampton, Va.—Six-footing manned space laboratory which could be operational before 1970 has been developed in conceptual form at the Langley Research Center.

Design features six rigid cylindrical sections joined by inflatable sections to form a toroidal shape. Three rigid, inflatable elements join the rim to a central, non-inflating section. The station folds into a payload designed to be topped off an Apollo service vehicle for the first crew. It is to be boosted into orbit by a single Saturn C-5 launcher.

After orbit has been established and the laboratory has deployed, the Apollo crew can return the station and begin setting up and checking out equipment.

There will be a "dwell-time" environment for a crew varying from four to 10 persons, takes in the station by additional Apollo vehicles refitted as ferry or resupply tank. Seven of the Apollo capsules could be docked at one time in the station.

Diameter of the station is 150 ft. It would rotate slowly to produce a low level of artificial gravity varying from 1/16g (the level of man gravity compared with earth's) to 1/4g at the outer edge of the rim. A small zero-gravity laboratory could be provided at the hub.

Total weight to be boosted into orbit approximately 190,000 lb.

Program in Time

Manned space laboratory assess two basic purposes. It furnishes a very special environment for experimental study, and it acts as a stepping stone into space. Langley's studies began with zero-gravity stations served from back, but they quickly changed to include artificial gravity for experimental reasons. This acquired station of the station.

At this point, human factors studies dominated the concept. Rotation rates

due feasibility of a rigid station whose elements are longer than a number of shrouds longer so that they fold to form parallel cylinders in a payload, but expand to the familiar toroidal shape after deployment.

Justification

NASA lists major uses for such a manned, earth-orbiting laboratory, most of which are tied directly to either current or possible future national missions in space and include: Orbital health experiments, crewwork study, controlled space systems experiments including biological and botanical tests, astronomical research.

These projected uses help to define requirements for the space station. First, they demand a large diameter, a large stable volume—this concept shows about 60,000 cu ft, equal to three large houses—and rotation. Operational considerations require automatic caution in space. The probability of docking, of electronic impact, or of people walking around inside require that the station have a natural stability for which the moment of inertia about the vertical axis must be very much greater than the moment about any horizontal axis. There must be damping of these disturbances.

Materials and structures must be compatible with the space environment. There must be control of the internal environment of the station. Power will be required. Protection against radiation and meteorites must be provided. Safety must be a predominant factor in case of fire, use of toxic materials, structural failure or the need to escape. Finally, a laboratory is no good if it runs out of equipment or personnel; there must be resupply capability.



RESEARCH PILOT, left, queries lunar landing simulator pilot model; right, artist's concept shows eventual station configuration.



There is much to do before the space laboratory concept becomes a reality. Many configuration studies will have to be made. The dynamics of the station will be checked in model form. Stability and orientation will also be checked the same way. In addition to North American's work, thermal behavior is currently being studied under contract to Canadian Aircraft Engineering Corp. Materials and structures will take shape and be broken here. Life support systems and power systems will be investigated for the laboratory.

In addition to manned space laboratory work, Langley also is studying spotlight piloting techniques for orbital maneuvering, for lunar and planetary approach, descent and landing as a series of annual simulations being developed in parallel form.

Progress of the simulation is to derive first impressions of the complexity

and difficulty of the task, and to get preliminary pilot reactions to initial maneuvering, control systems and navigation techniques.

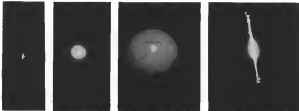
Preliminary results of studies of the problem show that the lunar landing technique with far nothing beyond current developments of guidance system and the standard lunar pilot. It seems as if the best way is to make the man the primary system with automatic systems as an aid, rather than trying to do the job automatically with man along for maintenance.

Results of these studies, and the present NASA approach to simulation of spotlight pilot tasks, seem to underscore the arguments of many engineers who, during all the modernized techniques showing the near impossibility of automatic maneuvering, kept arguing the task was no more difficult than bringing a ship into a dock during a high wind with a heavy sea running.

Simulator experiments and studies are being made with inventory, low-cost approaches. Simple inflatable structures are used for the structure of the launch. Plastic inflatables make a perfect "cinema" theater for projection of lunar approaches. A house-made planetarium, costing about \$150 and featuring a couple of Christmas tree ornaments as part of the optical system, serves as a star projector for one neighborhood simulation. In a modernized simulation, a few planetarium costing about \$15 projects a realistic sky background.

In one study, a simulated approach to the Apollo lunar center on the moon is created by projection of a filmed approach to a planet model, projected on the inside of a plastic indoor.

Another simulation study, now being developed for guidance and control techniques, uses an inflatable balloon as the right sky with the star pat-



LANGLEY STUDY of appearance of objects in simulated space environment shows point light effects on, 1, to 4, polished sphere, dull sphere, and rough-surfaced cylinder.



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Moon-Gravity Simulation

Unique simulator of the dynamics of lunar impact is among the test stages in Langley's Dynamic Loads Division.

It consists of an evacuated chamber, suspended by a cable running over a pulley, counterbalanced by a static weight equal to one-sixth of the chamber weight. Inside the chamber is a table to simulate the moon's surface and provisions for suspending and dropping a model of a lunar vehicle.

The chamber is loaded with this model and the simulated lunar surface, and then evacuated. To make the test, the model is released inside the chamber. It starts to drop at 6g. Just before it impacts the surface, the chamber is released so that it starts to drop at 50g. Resultant deceleration at impact felt by the model is therefore 106g, at the lunar equivalent gravity.

Following the impact, the test scale of the rebound is exactly that of the end test, so that the bounce trajectory can be plotted accurately.

First tests of the simulator are scheduled for Aug. 3.

tests projected by the 5300-plus-tonnage. A cockpit will be installed in the center of the spherical housing to study the problems inherent in deep-space navigation.

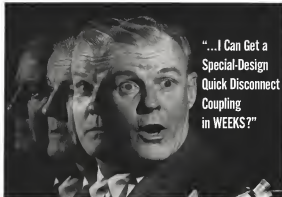
One of the moon ambulatory simulator projects here is a lunar landing and takeoff simulator, which will be used to develop technology which will determine the characteristics for an automatic rotation training simulator for lunar takeoffs and landings. To be in operation in about 17 months, this facility will be an outdoor geodesic structure housing a pilot's compartment on a geodesic module.

Propulsion module will contain two rocket engines and a system of fuel metering jets. A landing strut will support five-sixths of the vehicle weight at all times to simulate the lunar gravity.

Control consoles and docking simulator is being studied with a crane coupling added to a surplus gantry tower obtained from the railway. It will handle the last 1,000 lb. of approach of the Gemini to the Agena stage, which will be done visually in the test room.

Still another simulator study is in the area of the three-body reconnection problem. It involves the reconnection of two fuel tanks and a capsule subject is to get the tanks together without exceeding closing rates at a few tenths of a foot per second.

This center recently awarded a contract for still another type of simulator—for visual control of lunar landings—to Bell Aircraft Co.



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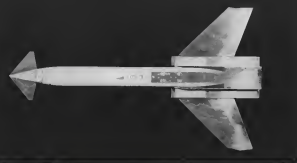
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SCAT-3 model is designed to reduce friction drag by means of very thin surface and minimum surface area. Model was tested in the Langley wind tunnel to determine performance and stability characteristics into the Mach 3 speed range.

NASA Evolves Two Basic SST Designs

Hampton, Va.—Two advanced configurations for supersonic transports have been evolved at the Langley Research Center as part of NASA's overall studies of basic research and technical support to the SST program.

One is SCAT-15—SCAT is the local acronym for Supersonic Commercial Air Transport—a variable-sweep design credited to John Stack, formerly NASA's director of aeronautical research. It features a highly swept wing which can be spread forward to increase the span and aspect ratio and to decrease the sweep angle. These factors improve low-speed performance and handling characteristics.

The other is SCAT-4 developed by Richard L. Whitcomb, who originated the area rule concept. This design is based on a fixed, highly swept wing with careful contouring of fuselage, powerplants and wing to account for the non-linearities of flow over such a shape.

Both these designs represent a major aerodynamic improvement over the USAF/North American B-70 configuration, but this is to be expected of designs which came along later and continued to develop. Both are aimed at slowing down the lift drag ratios much greater than those of the B-70, combined with the ability to operate efficiently at off-design conditions, such as subsonic flight in a holding pattern.

Parallel to these two approaches, Ames Research Laboratory is probing the aerodynamic development of the fixed curved delta geometry.

SCAT-15, with its wings pulled all the way back, looks like a thin delta shape with 75 deg leading-edge sweep-back. Spread, the wing leading-edge sweep angle reduces to 25 deg. If it

were a full-sized aircraft, it would be 172 ft long with a 164-ft spread wingspan. Fully swept, the wingspan is 45.4 ft.

Data from the SCAT-15 wind tunnel program, now nearly completed, shows the configuration to be getting the needed lift-drag ratios. Low-speed handling characteristics are expected to be like those of current subsonic jet transports, and the configuration shows promise of being able to operate at subsonic speeds over fairly short-range routes with efficiency and economy.

SCAT-4 starts with an arrow wing, so that the SCAT-15, in which the leading edge is swept behind the Mach angle to get a wing whose aerodynamic characteristics become like the subsonic case. But tests do not verify the high lift-drag ratios predicted by theory, the reason is that there is a substantial cross-flow—arabesque on the lower surface, induced as the upper surface—while changing the wing characteristics. Whitcomb's approach has been partially "cut and try," using many model tests

The configuration reduces to a highly swept wing with underwing inlets for the engines, and engine afterbodies which are like the swept-back bodies developed by Whitcomb for the Convair 990. The fuselage has negative camber.

First test data of the configuration does indicate lift-drag ratios less than current jets, but greater than a B-70 configuration. Supersonic lift-drag ratios are much greater than the B-70 type of geometry. Expected sonic boom intensity should be much better than a conventional delta because of the lower supersonic wave drag of Whitcomb's configuration.

Parallel Studies

Langley's responsibilities do not end with the aerodynamics of a possible SST configuration. The center also is concerned with the basic housekeeping, preparation, materials, structure, operating problems and handling characteristics.

Further, the configuration studies are continuing. SCAT-4 and SCAT-15 are not considered as ultimate layouts.

Beyond these defined investigations, linked closely to the actual design and operation of a supersonic transport, are some fundamental areas regarding characteristics. Assistant Director Lawrence R. Lofkin, Jr., elaborated on some of these points.

• **Laminar flow over the wing.** With about 25 years' experience in the study



157 MODEL, SCAT-15, prior to testing in Langley wind tunnel. Model is designed to reduce drag to a minimum between Mach 2 and 3. Note specially contoured, highly swept wing, engine nacelles mounted at the top and to the rear of wing, contoured fuselage.

of laminar flow phenomena, Lofkin feels it still has to locate the correct answer. Fluid objects look like one way, he feels, the numbers from the tests look right. But secondary air or fluid has to come from somewhere, engine air is best, being readily available. But what is the price paid for that air? It is acceptable.

• **Effects on highly swept wings under load.** Langley ran those tests on a B-70 B-70 some years ago, measuring the distance upstream of the structure as much as 100 ft and trying to check these results with some static load work. There are many unknowns here, Lofkin said.

• **Jet exit problems.** Engine exhaust and intake areas don't match over the flight performance range; their areas have to be matched by combination of variable geometry and bleed. Langley is performing some of this kind of work in the B-70, mainly now, but possibly the engine inlet problem belongs to Ames Research Center.

• **Turbulent friction drag.** It has never been measured at Mach 3 and the simplified models it is used for basic concept of variable sweep for SST and is shown certified as the 7 x 10 ft. wind tunnel.

the Langley data-computation equipment and fed to NAEP by a leased telephone line. The two areas may be the variables will be put into relative air traffic situations to help develop air transportation requirements, crew duties, communications needs and the like.

One of the very important by-products of this simulator should be more accurate determination of fuel reserves needed in fly in realistic transport situations. Calculated data is little better than actual here; the weighted system approach, using the characteristics of any assumable SST fed through the data-computation equipment and the simulator itself, should provide values that will be much closer to the actual fuel burned.

First complaint that anyone might wish is affecting smooth performance at subsonic air beginning to be heard from pilots now and the supersonic transport payload will be worse in its response to waves, gusts, and turbulence (to Langley engineers).

Ambient studies are progressing.





PHOTO-CONTROLLED, jet-driven research model of supersonic bomber and a flexible, lightweight auxiliary wing are tested in free flight in the Full Scale Tunnel at Langley.

calculating response of the SST at its center of gravity, cockpit and other locations, and among known major problems is determining optimum locations for nose gear and main gear, so that their geometry doesn't reinforce the oscillations set up by turbulence.

Work on the nose boom problem involves the construction of the most delicate and useful wind tunnel models that can be tested in jet area. Imagine a complex Concorde B-58 with a wing span approximating one-quarter of an inch. The model, and others like it, tested down from conceptual layers, are mounted in supersonic wind tunnel test sections and "blown" at speeds corresponding to those of a typical SST flight profile. A test profile is used to remove the pressure jump across the shock wave and the results are measured in terms of the strength of the nose boom in the pressure rise at a point on the ground below.

This trailing edge noise shows first correlation with full-scale flights, and is pointing the way to less possible noise in alternate the same boom. General investigations of the nose boom problem have also pointed out new aspects. One of these is that the shock wave strength on the ground is amplified when the airplane is accelerating in climb or in level flight, and also when the airplane is twisting at supersonic speeds. This amplification may well be the most aspect of the boom.

Supersonic transport problems are concentrated in areas of materials and language on the ground charts of the Structures Research Division headed by Richard B. Helderich.

Materials, one of the big grey areas in the vehicle design, are being

scrutinized here by the usual process of testing after exposure to elevated temperatures for periods of time. Hidden life stresses are combined with some old and new failure data materials, aiming at a final test exposure of 20,000 hr. at elevated temperature. During that time samples are taken from areas in possible rupture and tested for data material, of stress-strain characteristics and notch sensitivity. But Helderich points out the difficulty: There is no time to compare time. If the airplane life is going to be at 30,000 to 100,000 hr., then's the way to test materials for a shorter period and be absolutely sure of their properties after the longer interval has passed.

One strong guess is that many materials may be expected after only 1,000 hr. of exposure, during which time the loss to much of that strength or resistance to deterioration, that the objects won't maintain any kind of strength over a long-time exposure.

Most of the fatigue work hinges on the supersonic transport. Fatigue tests are run on materials which have been exposed to high temperatures; the tests themselves are performed at room temperature. The engineers are looking for a link between what they know of fatigue and what they assume the load exposure will be. Now, they expect most fatigue effects to occur on the ground, as in climb and landing. The cruise phase is expected to be a minor contributor.

In addition to Langley's supersonic transport program, the facility is engaged in a continuing older aerodynamic program and in performing research in some new areas like propellers. There are typical projects.

- **Multi-engine aircraft.** Commonly identified and frequently conducted with Department of Defense's TFX (twin-engine fighter) requirement, the Langley work on multi-engine aircraft has centered on the development of an acceptable variable-sweep wing. Wind tunnel and analytical work has gone into the evolution of the currently favored shape which takes the form of a diamond in supersonic flight at low altitudes and spreads out to a straightening form for subsonic stream shapes. With that kind of position, NASA hopes a two- or three-engine aircraft will be able to cross the Atlantic unrefueled, fly at supersonic speeds close to the ground, handle the air superiority in intercept missions at altitude for the Air Force, and fill the Navy's requirement for an supersonic and combat jet patrol.

- **V/STOL aircraft.** Langley engineers have been using the free-flight model technique, blowing dynamically similar models in the full-scale wind tunnel, to get a fast qualitative evaluation of new, particular designs. The test work has been supplemented by firing full-scale test vehicles such as the Vertical F-22. But they note the British position: "The British have said we NASA expect." The British Short SC-1 has gotten much more data than is possible

Hawker P.1127

Development of the Hawker P.1127, British prototype of a subsonic V/STOL fighter, was supported technically by Langley Research Center in two critical areas.

Free-flight dynamically similar model of the aircraft was flown on tandem and on the full-scale test in short bursts from hovering to forward flight.

Tests of the propulsive system were made with the dynamically similar model in the 16 x 16 ft transonic dynamics tunnel with full simulation of both engine intake and jet pipe exhaust flow.

Flow simulation was done with a hydrogen peroxide system which generated steam and oxygen at high pressure and volume. The primary steam, which simulated the exhaust, was used also to drive an engine pump which drew in air through the intake, simulating the inlet flow. The peroxide was pumped in through a compressor such line, which provided enough control so that no other model support was needed for the test.

Other parameters measured were effects of the ground proximity, conditions of the aircraft due to decreased pressure on the fuselage bottom caused by reflexion of the engine exhaust, and an ingestion of the engine air. Much work was done also in the field of dynamic stability, particularly in response to forced oscillations.

with model work here. All our exploratory dynamics work with models has already been done, full-scale by the British. For the low-speed stage, NASA engineers think they have found the best solution in a combination of the following and deflected algorithms types. That's what current test work seems to indicate. Many questions remain, one of these is how to get higher speeds than are possible with propellers.

- **Subsonic transport.** It seems possible to produce modern generation of subsonic transports with increased productivity through expansion of present aerodynamic and propulsive state-of-the-art. By using combined and twisted wings, the lifting area might be pushed to values around 30 ft. Much numbers approximating 0.9. A future turbofan engine could enter the propulsive picture, and the combination could provide the main generation of subsonic, highly efficient transports.

- **Rigid-rotor helicopter.** NASA soon expects to have a tethered rigid-rotor helicopter—so as they prefer to call it, a helicopter-like helicopter—flying. The hover is difficult. Said one NASA expert: "The British Short SC-1 has gotten much more data than is possible with model work here. All our exploratory dynamics work with models has already been done, full-scale by the British. For the low-speed stage, NASA engineers think they have found the best solution in a combination of the following and deflected algorithms types. That's what current test work seems to indicate. Many questions remain, one of these is how to get higher speeds than are possible with propellers."

- **Fingertiles.** This development of the flexible wing in progress. Testing is planned in the 16 ft transonic dynamics tunnel of an aircraft similar Apollo wing, a inflatable pumphlet type being built for Langley by Goodrich. Another current project is the design of inflatable boom controls to the Ryan Stearman tested aircraft to improve its handling qualities. One major problem with these flexible wings is to keep the trailing edge stiff, obviously, one of the best ways to doing pitching moments violently as a wing is to provide the trailing edge.

- **Vigil program.** This program, which involves firing rockets in selected noncritical situations, has furnished much useful data since its inception almost 30 years ago. The rockets furnish a true history of velocity (V), vertical acceleration (g), and altitude (V), so that the loads can be related to their exact gear, maneuver, or ground roughness. One disappointing result was the 20 or so Vg records now being in jet transports. Unusual flight events occur much more frequently now than they used to. The



POSSIBLE CONFIGURATION of multi-mission fighters showing operation of wing sweep and other changes when that required by supersonic flight at low altitudes (top) to intercept and landing configurations (bottom).



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MODEL of supersonic transport aircraft.

transports are being operated closer to, and sometimes in excess of, their design speed limit. There are several times as many maneuvers per flight hour for the jet transports as there were for piston-engine aircraft, this may be associated with increased training time.

• **Runway shock.** A NASA report is the basis for FAA's current "half-inch" rule, which forbids turbulence if there is a half-inch or more of shock on the runway. Langley performed tests on the landing truck, to measure the drag of runway shock. When FAA made some full-scale tests, that agency got twice the drag reported by NASA. The difference was the added drag of flap, landing gear, and interference between front and rear wheels on the landing gear legs. Now NASA is revising its test apparatus to simulate flaps and bogie gear, and expects to get more accurate measures of its drag due to shock.

• **16- x 16-ft transonic dynamometer tunnel.** This national research tool used to be the 19-ft diameter, circular throat, low-speed, pressure wind tunnel, but during the early 1990s it became apparent that a large-scale transonic open-circuit tunnel would be very useful. The 19-ft tunnel was converted to a 16- x 16-ft slotted-throat test section which can be run with air or Freon at speeds between zero and Mach 1.2, using only 20,000 hp. Electrically heated models are run in this tunnel, as Freon, a suitable scale model simulates the similarity parameter identity. One problem now facing attention is venting models. Langley engineers devised a mount using a pair of wires to mutually perpendicular planes, wires run over pulleys inside model.

• **Main program.** Besides the specific applications to the supersonic transport in the sonic boom program, Langley is involved in more general aspects of noise. The increasing volume of our plant's variable to the landing, not the takeoff, of turbofan-powered jet planes stimulated this interest. Past results of investigations show that two noise aspects in spurs in a narrow-frequency band accompanied on a broad-band noise spectrum. The noise is very highly directed forward of the engine, just off the axis.

Major advance in cryogenic cooling

Miniature turboexpander increases closed cycle system reliability

Actual size turbine wheel for 250,000 rpm, gas lubricated turboexpander in A/R research closed cycle systems

Garrett-A/R research is completing development work on closed cycle nitrogen, helium and neon systems using a tiny turboexpander in place of a piston expander.

This promises to dramatically increase system reliability and service life because all wearing surfaces, valves and crankshafts compressing loads have been eliminated.

Thus compact, lightweight systems for space, portable applications, IR oil cooling and computer components are ideally suited to commercial applications as well as military ground and aerospace uses.

A/R research was first in production with an open cycle IR cooling system, and has already produced a closed cycle nitrogen system. The company is now working on military programs for 30°K and 4°K closed cycle systems.

Utilizing its experience in a world leader in lightweight turbo machinery and systems cooling, A/R research is also developing an oil turbo-machinery closed cycle system incorporating a turbo compressor as well as turboexpander.

Your inquiries are invited.

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Be fussy

Two things determine whether or not a particular printed circuit connector is "right" for your application:

1. How the printed circuit board mates with the connector; and
2. How the connector connects to the rest of the system.

Toler mating. For example. Besides having the correct number of contacts, a printed circuit connector must hold the board securely whether the board happens to fall at the high or low end of thickness tolerances.

IT TAKES TIME

These considerations convinced Amphenol engineers that no single contact design could satisfy the requirements of a wide range of applications. So they designed three contacts that will.

One used in Pin-Cle® connectors, looks a lot like a tuning fork with lips. The circle lip design makes contact overstrapping, or "strapping" impossible—even after repeated insertions. The contact's long spring base also enables it to accommodate boards that range in thickness from .055" to .075", while doing an excellent "mating" job.

LAST WORD IS

Not one every application requires the Pin-Cle "lip." For that reason, Amphenol engineers designed connectors with ribbon contacts that mate with a gradual wedge like form. In

blind mating applications, gradual mating makes the feeling of correct mating unmistakable. That's the thing when your equipment may eventually be maintained by installed and less-concerned personnel. Ribbon contact wedge action also makes it possible for connectors using these contacts to accept the same wire range (.055" to .075") of board thicknesses as do Pin-Cle connectors.

Finally, advances in micro-miniaturization (like Amphenol-Borg's miniature® pre-fabricated connectors) meant that three-times-over before connectors were needed. Amphenol's answer was the Micro-Min® receptacle and printed circuit board adapter. Micro-Min contacts are actually tiny uplays of beryllium copper wire, formed in a precisely designed arc to assure firm circuit board retention. This unique design makes it possible to space contacts on .050" centers and crowd 19 connectors into a hole more than an inch of space.

TERMINATIONS COUNT, TOO

"How to connect connectors to the rest of the system" also merits a good deal of consideration. In some cases hand soldered terminations will do just fine. In others, higher volume requirements call for high production rate methods like dip soldering and wire-wrapping. Some engineers prefer taper pin terminations.

Our printed circuit connectors are available with contact tails designed for each of these termination methods. In addition, adapters are available for use in connecting printed circuit boards at right angles to each other or in modular arrangements. We make printed circuit connectors with hermetically sealed contacts—or still others with coaxial contacts.

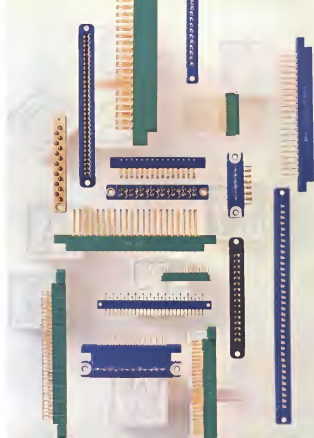
Take your choice

Any Amphenol Sales Engineer or authorized Amphenol Industrial Distributor will be happy to discuss printed circuit connectors found with you. Or, if you prefer, write directly to Dick Hild, Vice President, Marketing, Amphenol Connector Division, 8550 S. 34th Avenue, Chicago 90, Illinois.

© 1981 Amphenol-Borg Electronics Corp.



Wedge action of Amphenol ribbon-type (D) and long spring base of Amphenol Pin-Cle connectors (B) assure firm printed circuit board retention, whether board happens to fall at low (.055") or high (.075") end of thickness tolerance.



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In its Golden Anniversary year, the company founded in 1912 as Gilfillan Brothers changes its name to the Gilfillan Corporation. Under the new name and "Tanard G" signature, the same progressive management will continue to maintain policies and capabilities that have established Gilfillan's worldwide position as prime contractor of complete radar systems to the military services and civil agencies of the United States and 40 nations around the world.

THREE FRAMES OF FILM from Project Ros. Right: hot show formation of heated ring in region of interface between rocket exhaust and vehicle flow field. First frame now takes shortly after second-stage ignition, second frame shows formation of ring, and third frame is the start of plume flow around the nose of the vehicle.

Re-entry Heating Is Under Intense Study

Houston, Va.—Re-entry heats up to 30 times as great as those experienced during ballistic missile re-entry are being studied at Langley Research Center as part of a comprehensive program in re-entry physics.

Speed ranges covered start at satellite speeds around 26,000 fps, and extend to the hypersonic velocities—greater than 35,000 fps—that are associated with return from planetary voyages. Test velocities up to 47,000 fps, have been achieved in flight tests using multi-stage rockets firing on both the upward and downward legs of the trajectories.

In addition to measurement of heating, other studies are attempting to define the radiative signatures of different materials at re-entry velocities, to explore the ionization value and behavior of protective materials and to investigate the ways to combat communications loss during re-entry.

Flight tests and wind-tunnel techniques have with chemistry and physics are part of long re-entry programs here. Traillblaze, Fire Stage Scout, Ros, and Fire. In addition, tests are being run in a hypersonic Mach 12 wind tunnel with a 15-in. square throat to aid correlation of experiment and theory.

Radiative Heating

Problem of re-entry heating of manned vehicles remains, from the physicist's viewpoint, a different issue than that of missile re-entry. The heat load increases out of all proportion to the speed increase. At 35,000 fps, satellite velocity speeds up to 26,000 fps, and re-entry heating is the problem. Heat is transferred by convection from the hot entering gas cup to the vehicle.

At speeds around 35,000 fps, the heat input is at about 10,000 ft/sec, and the heating begins to "spike." The vehicle now gets heat energy from both convective heating and the radiated heat of the hot gas cup. This means that an Apollo vehicle, re-entering the earth's atmosphere at about 35,000 fps, will be subjected to more than twice the heat load as Mosier, as in other re-entry from satellite speeds.

Further increase in heat load goes with added increases in speed, but the relation is exponential, with the heat input proportional to a value somewhere between the 15th and 20th power of the velocity. If the speed

doubles, the heat load may increase one million times.

Pre-heating heating occurs at three angles: convective streaming from the re-entry from the hot gas cup. That source radiates away energy at short wavelengths and prevents the upstream gas before it comes near enough to pick up the longer wavelength radiative heating and eventually the convective heating.

What can be done about this? Right now, ballistic missile nose cones can be patented to use the slightly better Marcani canals. Apollo India Republic. Beyond that, Langley engineers frankly admit they don't know the answer.

One of the most important avenues hopefully will define the share of the convective and radiative heating, and comes by being down the proper exponent of velocity to use. It is 13, or 23, or where does it lie between? Traillblaze members hope to find out.

Traillblaze

Proving matter with the fire and seven-stage Traillblaze rocket vehicles are planned to produce information on the gas space and the radiative and other radiative and optical measurements may be made. The program is a cooperative one, with NASA getting funds from Defense Department's Advanced Research Projects Agency by way of Lincoln Laboratory at the Massachusetts Institute of Technology.

Flight path of the Traillblaze shots is called a "bouncing" trajectory, the vehicle shows out from the Wallops Station launching site under the dome at the first two or three stages. It ascends over the top of the trajectory and then is turned to head toward, but not at, Wallops. The ascending stages fire on

the downward leg to produce the required velocity, and the re-entry event occurs about 150 mi. down range from the launch site.

Traillblaze-1 is a six-stage solid-propellant rocket vehicle about 56 in. long, weighing 7,700 lb. The first three stages—Boost, John, Nike and TX-77 Lower boosters—carry the third stage to peak altitude of about 380 mi. Re-entry speeds are produced by a TX-48, TX-55 and a five-stage rocket mounted on the downward leg. One experimental Traillblaze-1 shot added a shaped charge accelerator at a seventh stage to get a first look at re-entry velocities near 44,000 fps. Eleven out of 18 Traillblaze-1 shots fired have produced useful data.

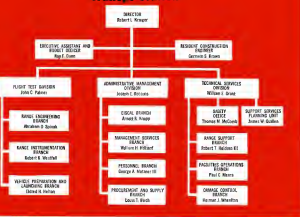
Standardized Vehicle

Traillblaze-2 has been standardized as a five-stage vehicle using an XM-53 Center first stage with two Boosters, rocket motor and a second-stage TX-77 Lower to boost the other two stages to 200 mi. altitude. Standard third stage is the X-248 Atlas motor, and the fourth stage is a NASA-developed 15-in. diameter spherical motor. For the first shot, a fifth-stage fireball shaped motor and a sixth-stage shaped charge accelerator were added, to produce a re-entry velocity of 47,000 fps, highest yet achieved artificially. Two more Traillblaze-2 shots are currently scheduled.

Purpose of the firing with the five-stage Scout is to study the performance of protective materials. The re-entry package is instrumented and protected with a Telon ablative liner which is transparent to radio frequencies. Video images, being shown, has between 35,000 and 38,000 fps. During the re-entry, the ionization sheath prohibits telemetry transmission from the package. To transmit this, NASA uses a sub-band, continuous-loop type recorder which picks up data and stores it for after 60 sec. Since the blackout doesn't usually last that long, return of data taken during the blackout is assured.

Fire Stage Scout uses the standard

Wallops Station



Wallops Key in NASA Research Circuit

Flexible facilities at launch site used for 250 shots yearly; competence built in tracking, acquisition.

Wallops Island, Va.—Wallops Station, an operating base for scientific experimentation with rocket-propelled vehicles, performs an essential feedback function in National Aeronautics and Space Administration's research circuit.

Primarily, the job of the station is to conduct tests, and to support test activities with instrumentation development, launch facilities, tracking and data acquisition and recovery of the payloads.

Working under management from NASA headquarters, the station performs a wide variety of experiments for NASA centers and for other groups both in the American and foreign scientific community.

In its testing function, it helps to close the loop that runs through research and development of vehicles, of scientific payloads, and of experiments in the new sectors of space.

Beyond the formal language of the mission statement for Wallops Station is a long list of jobs done over more than 20 years in the business of boosting

scientific studies, checkout tests for the Echo satellite, and launches of tests related to Project Mercury. From Wallops, two satellites have been launched, using the Scout sub-propellant rocket. To Wallops, foreign countries have sent teams to view, study and to do experiments under the watchful eyes of experienced NASA launch crews.

In director Robert Kasper's office hangs a citation addressed to him and the personnel of the station for one extraordinary mission and one disaster to the victims of this year's late winter storms that hit and flooded the Atlantic Coast. Wallops personnel saved for several hundred people who had been evacuated from danger areas and flown into the railroad base where they were housed in the hospital and other personnel buildings until the Red Cross was able to take over in saving the winter victims.

Since its inception, this all-weather range—the only one in the world—has launched close to 5,000 experiments

Current rate runs about one shot per dry good weather, at 210 annually.

Among the typical experiments done by Wallops crews are the series of its checkout checks related to the Echo space communications satellite. The launches are intended to prove out the system of reception of the deflated and inflated spheres, and to follow that with a demonstration of the actual inflation. Several cases of spheres were used for the purpose, both for convenience and to provide some spare efforts as fallout data.

Secure Test

When the second Saturn blasted tons of water into space to build an ice-cold cloud that could be seen for miles, its success hinged partly on a similar test done at Wallops about three months before in order to check the technique and the logistics.

The seven planes shot under Langley's Project Rime, Turbblasts and six-stage Scout jet flew low. The Explorer 9 and Explorer 13 satellites were released from Wallops by Scout rockets.

Apart from the capability of launching vehicles, Wallops has also developed a strong competence in tracking and data acquisition. The prototype Mercury tracking station, located here, is used to test proposed changes or new developments in the system. The station also is the principal East Coast leader for the Texas weather satellites.

A major role of the station is in education and training of other groups who come to Wallops for initial guidance. Earlier, the groups were from American universities and research institutes that became associated with upper atmosphere studies or similar projects. Wallops technicians worked with them, aided them in assembling vehicles for

Wallops Station

NASA's Wallops Station is located on a small island off the Virginia coast near Chincoteague, and is the nearby active base. The launching site for such launches and avoiding rockets is on the island, the mainland site includes offices, shops and trading facilities.

Total cost assigned by NASA is \$137 million. Value of the plant is \$24,175,000.

Operating cost for Fiscal 1962 was \$7,546,000, for Fiscal year, NASA asked for an increase to \$8,126,000. Construction program last year cost \$7,965,000, the fiscal year's construction is budgeted at \$5,180,000.

Wallops Station staff, which totaled 399 for Fiscal 1962, was budgeted at 460 in NASA's request for Fiscal 1963 authorization.

them, firing, and helped them through the countdown and launch.

Now the groups that come to Wallops are from other countries, 16 of them at the last count. Twelve foreign groups came because they planned to establish their own national ranges. Four countries test Satoms in the air at Wallops, in residence, working on a day-by-day basis with the resident technicians and some of the expertise had been transferred.

Wide contact has a cause to Wallops for the purpose of joint experiments or for coordinating their own experiments for coordination. Most recently, there was a series of joint shots with Japanese technicians.

Pakistan sent a team which stayed on nearby learning the business. Test teams from Wallops went to Pakistan to serve as consultants while the Pakistan set up their own range and

launched three annual sounding rocket shots with solid-rocket closed experiments. The same mission was followed with a group of Indian technicians from their range in Sri Lanka. A Soviet team has just left Wallops, after being in residence there for some time. Presumably, a similar mission will follow for starting the Swedish range.

But in spite of the increased pace of activity here, the program growth at the station is not rapid. The major reason is the flexibility of the existing facilities. Wallops now has five launch sites but they serve multiple uses and utilize multiple launches—one has an even dozen of them. One pad handles Scout launches, and another is planned as the tempo of that program increases. Another is exclusively for Thor-Delta shots now.

Pads, tracking stations and the rest of the buildings associated with the experiments are located on Wallops Island. The remainder of the administration and supporting facilities are on the mainland, in the old Chincoteague Naval Air Station. NASA left her in the satellites in a move aimed primarily at keeping the local economy at a constant level.

Now Wallops officials are beginning to see the Chincoteague takeovers as a global extent of it in a whole elephant. Shortly after acquiring the site, a team went over every square foot of building and ground space, evaluating a system fireproof plan for NASA. They considered and laid down at more than 200 buildings, mostly wooden "barns" structures that are built to last for 10 years but need for repairs. What is left largely consists of non-permanent brick buildings, and NASA is gradually working into them, rehabilitating them and moving in as the staff and facilities expand.

RADIO ATTENUATION MEASUREMENT (RAM) experiment is pushed. For launch at Wallops, last tests experienced some loss.



COST & LEAD TIME REDUCED

Development And Production Costs Cut 50%

FAIRMINGDALE, L. I., N. Y.—The accelerated rocket motor costs of HYSTRAN reinforced plastic vessels by Lamtex Industries, Inc. substantially reduce costs and delivery time as compared to conventional cases made of steel.

Development costs for a typical HYSTRAN case are one-quarter those for a similar steel case. Production costs for the plastic cases (after all development, tooling, and design modifications have been completed) are expected to be one-half those for comparable steel cases. Tooling costs for the HYSTRAN cases are approximately one-quarter those for steel cases.

Phase: 3 Months
Lead: 24 Months

The large reinforced plastic cases produced at Lamtex were delivered five months after the start of the program, including all development, tool design, and fabrication. For control, the delivery lead time required for comparable steel cases is in the order of 14 months. With the delivery time for production-molded steel cases (after all tooling and design changes have been completed) is almost one month after ordering. Lamtex can deliver production-run HYSTRAN cases in two to three months.



Worked in wet place, Lamtex's HYSTRAN rocket motor case is fabricated primarily by hand, inside pots fitted with special Merl tube linings.



LARGEST ROCKET MOTOR CASE made of Lamtex HYSTRAN resin completes its submersible welding machine applies final layers of fiberglass and epoxy resin to attach handling and supporting clamps at both ends of case.

Lamtex Produces Largest Fiberglass Reinforced Plastic Rocket Cases

FAIRMINGDALE, L. I., N. Y.—Sold propellant rocket motor cases of reinforced plastic larger than any previously produced have been developed and manufactured here by Lamtex Industries, Inc. The 22-foot long, 55-foot diameter cases are made of HYSTRAN, Lamtex's exclusive filament wound reinforced plastic.

These lightweight plastic vessels were produced for Thrust Chemical Corp. as part of a Project Development Program to investigate reinforced plastic for use in large rocket motor cases. The program is sponsored by the Air Force Systems Command, Manufacturing Technology Laboratory, Chemical Engineering Branch.

Greater Strength Per Pound

An outstanding advantage of the HYSTRAN reinforced plastic rocket motor case is its increased strength-to-weight ratio. In a conventional propellant design, Lamtex reinforced plastic cases carry a weight only 65% that of comparable steel cases. A more important, lightweight design is expected to reduce weight further to just 60% of steel cases.

Design And Performance

Additional advantages result from the use of HYSTRAN for rocket motor cases include:

Thermal resistance, inherent in reinforced plastic, as evidenced by the conductivity of rocket thrust flight. HYSTRAN also retains strength under heat—usually without any special external insulating materials.

Superior corrosion resistance. The same resin used in HYSTRAN can frequently applied to multiple structures to improve corrosion resistance.

Safety factors in metals, because the reinforced plastic is non-explosive and non-sparking.

Impact and shatter resistance. A basic characteristic of HYSTRAN is its relative durability. Impacting back support results in no cracks and blunts.

Red in handling. There are no integral parts of HYSTRAN filament wound cases. Additional support parts are not required prior to casting of the propellant.

No costly assembly joints in HYSTRAN structures, alleviating a problem which plagues all high-strength-to-density metallic structures.

Make Own Equipment

Lamtex Industries, producer of these reinforced plastic rocket motor cases, designed and built its own filament winding machine, using no standard machinery or process procedures existed. As an industry recognized leader in this new field, Lamtex has processed the design of filament winding

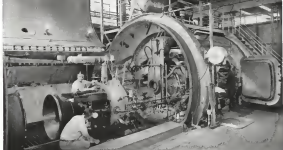
equipment, including new semi-controlled machines.

Quality And Reliability Are Important

With new materials and techniques being developed almost daily, continuous testing and quality control are necessary to insure the high degree of reliability required. A typical example of this involved the simple filament winding of a vehicle model in less than a week, repeated through for use in the large case.

Lamtex Plastic Products

Lamtex is currently producing high quality reinforced plastic products for a wide range of industrial, commercial and military applications. Reinforced plastic products in filament wound propellant tanks, torpedoes, battery cases, radomes, nose cones, high voltage insulators, pressure vessels, high strength container structures, submarine hulls, compression and vacuum modified parts, rocket launchers tubes. A list of civil space-age equipment and military products are included: see POLARIS, PERISHING, MERCURY, VOSTOK, EDWARDS, MERITMAN, BANGOR, SCOUT, NEEZEUS, LAM and a variety of NASA projects.



HIGH-ENERGY fuel rocket engine, using liquid hydrogen and fluorine, is tested for test firing in near-space environment.

Lewis Aims at Future Propulsion, Power

Center explores chemical, nuclear and electric engines, technologies to support future spacecraft.

Chemical-Propulsion and power systems for future space probes and spacecraft are twin goals of the major effort at the Lewis Research Center.

In these broad areas, the job is to create things that will lead to progress 10 years from now. "We're staring toward the future," says Dr. Abe Silverstein, director of Lewis, "toward Saturn C-5 types of spacecraft in orbit for civilian or military purposes. For this, we need a power source and we need propulsion. They have to have long life and high reliability. On job is to find out how you get there."

For today and the immediate future, Lewis researchers are busy in a variety of support tasks and in early research programs in the Apollo manned lunar exploration, the supersonic transport and the Navy nuclear reactor.

These latter jobs faced a shift in the traditional approach of Lewis toward its work. Once almost entirely devoted to propulsion research, Lewis now adds to that job the management of development projects, such as the planned Apollo lunar-landing module, a specific responsibility assigned to it by National Aeronautics and Space Administration headquarters. Lewis gets the job because the propulsion system dominates the module.

The task of the center would include management of the entire effort that will be done, as well as technical support, systems and engineering evaluation, quality assurance, and a number of other jobs that are in the center's research and engineering experience.

These new technologies of management are in an area where many research scientists are strangers. Come

month, the center has the job of "engineering" most of its specialists in an additional program that studies the specific problems connected with management activities.

Management Structure

The spectrum of work demands a broader organizational structure, than has been developed at NASA's center. Last February, Silverstein announced a new management structure for the Center which split the house into research-oriented and development-oriented divisions.

Silverstein's deputy, director and long-time associate, Eugene F. Merriam, heads a second division in research, directed for research. Bruce T. Linder is the associate director for development. In their two sets of divisions in the bulk of the work at Lewis.

The balance of personnel will have research, about 500 professional people, compared with about 150 in development divisions.

Naturally, there is some overlap

There is no doubt, research on the development side, changes to the need to maintain research and technical competence, and development work on the research side, in support of work on specific projects.

Interference through this work is no longer being, based on a more complex level than ever. Parts of the test program still are done at the center site, but other parts involve basic projects, dangerous chemicals or nuclear facilities, and can only be done at remote sites. For this purpose, Lewis operates the Plum Brook Research Station near Sandusky, Ohio, about 10 mi from the center.

These operating divisions of the Lewis Research Center receive their support from the standard administrative and service organizations.

There is no organization not shown on the chart that is attached to Lewis for headquarters purposes. It is the General Administration of the Space Nuclear Propulsion Office, a joint agency of NASA and the Atomic Energy Commission. In functions related to direction of research work on the Reactor Nuclear rocket program, as managed by the SNPO and monitoring industrial liaison with reactor propulsion research at Lewis.

With air-breathing propulsion systems out of the house, we've got to get underway by March 4 long ago," says Silverstein-Lewis, propulsion research center on three types of systems.

Chemical propulsion, which starts with fundamental analysis work in

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Lewis Research Center



chemical kinetics and goes through many concepts to detailed construction of components such as pumps and turbines, tanks and insulation. Supporting materials work space, the temperature range from the elevated values in a rocket nozzle to the cryogenic liquids in a fuel storage tank. Special problems include combustion instability, open-circuit combustion, solid-propellant rocket thrust and control.

• **Electric propulsion.** which studies three types of engines: electrothermal (arc jet, resistance heater jet), electro-chemical (plasma acceleration) and electrostatic (ion acceleration). One promising approach in this field is the electrothermal-chemical ion engine developed at the center and scheduled to fly on the first SERT (Space Electric

Rocket Test) flight of a Scout rocket. Further work is being done on beam-molecule impact, cold-cathode particle engines and other advanced devices.

• **Nuclear propulsion,** which includes basic reactor design, nuclear-electric conversion systems, reactor dynamics and similar projects. Lewis' activities do not include management responsibilities for the Reactor nuclear propulsion program which is assigned to the SNPO. Lewis supports the program in consultation of technical studies and other consultative work. Applied research projects in the Center line support Reactor activities. Examples are nuclear studies, single and two-phase heat transfer studies, and high and moderate boiling studies. Additional theoretical work is being done by

groups at Lewis in the field of particle physics and heat transfer. The nature of this work is general, but it might lead to specific applications.

Related Areas

Once the various concepts are applied to a propulsion system, it must fit through pumps and valves and lines to the tanks. In space systems, industries add another portion.

One major area in which Lewis has prime responsibility for development and a project to manage is in the generation of power in space. Currently, the center manages the Supracell, a 30-kilowatt power generating system for deep space missions.

But we're also looking to power



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very much greater than 50 km," said Silverstein. "When you send a space probe as far off as Jupiter, you need power levels in the megawatt range to send data back."

In space, most of the heat waste is wasted and has to be rejected. The only way to do this is by radiation cooling. "So radiation might become a great big factor," Silverstein said. "And we're talking about acres of radiating surface now. You want three-walled radiators, but what about the material problem? How about liquid sodium in the radiator itself? That's one of the kinds of problems we keep trying to solve."

Long space voyages mean operations for 20,000 to 30,000 hr at temperatures never met before with materials never tried under those temperatures. The space vehicle operates over a temperature range from the cryogenic to several thousand degrees in the middle it runs on surface liquids for cooling fluids. It may be hit by micrometeoroids subjected to severe doses of radiation. Its surface finish may be changed as much by scattering-long atoms and molecules through collisions with particles as it would be by incineration today.

This environment generates new sets of requirements for every type of work done in space. Metallurgists are used to the simpler problems of high-temperature materials for gas turbines, have to turn to extremes at both ends of the temperature scale besides selecting their fast specimens to nuclear corrosion. Test facilities have to run at hard vacuum levels and at each end, before, and applied insight and test tools have to be created.

On a more mundane level, Lewis metallurgists have been contributing a major share of the country's effort in materials choice and development for the supersonic transport. Here the work involves an increasing alloy of steel and titanium and on testing some of the high-temperature stress tests as Room 41 under conditions that began to



THICK COFFEE engine and nozzle are used for heat-transfer studies at Plum Brook.

approximately those which the supersonic transport will impose.

Other support work at Lewis for the supersonic transport program includes some analytical studies of propulsion, but there is no current program for propulsion system tests in development. Basic Lewis are being asked a case of five project management offices for these aspects.

•**Apollo heat-loading models.** This office was to have the management job of the models remains in the Apollo program, and handles all contractual work as well as plus in-house support jobs. The models have an entirely new degree of sophistication, the engine has to start, stop, throttle, control mixture and combustion for periods up to 15 min of operation time. That's all of the model will be on the order of 50,000 lb. The model has to live in a different environment from any previous propulsion system. There is a three-day cold soak on the rig; in the mean, and the heat environment requires a different set of conditions on top of the conditions imposed by the operational requirements.

•**Chemical rocket propulsion.** Most of the work handled in this division is contractual, and is aimed at advancing the technology.

•**Electric propulsion.** About 50 contracts to be awarded, composed the major effort here. This work was transferred from Marshall Space Flight Center because of Lewis' in-house competence in electric propulsion in the research side. The group there is probably the largest working on electric propulsion in the country.

•**Nuclear electric power generation.** This is the office charged with management of the SNAP-8 program. It also is monitoring contracts and Lewis Research on liquid metal properties, compatible materials, heat transfer, etc.

•**Solar and chemical power.** This group manages programs in the areas of thermoelectric, solar dynamic, fuel cells and batteries, and less contracts for its central work on various related subject areas.

One of Lewis' most important divisions is concerned with reliability and quality assurance. Functions of this group include establishment of specifications for environment, test acceptance, quality and similar subjects.

Management Training

Recent studies courses covering subjects have orientation through technical management as part of the system is established at the Lewis Research Center for training engineers and scientists to be managers of program and processes.

Training of new employees through an orientation course, ranging through new areas of training mission, and reviewing the facilities, services, projects in the research and development division, where they are done and who is doing them.

For non-employee employees, there is an fast technical training in chemical propulsion, electric power production in space, electrical propulsion, and FRET. FRET is to bring the present staff up-to-date on current state of technology outside their own specialist fields.

Lewis Research Center

Lewis Research Center is located on 310 acres of NASA-owned land adjacent to the Cleveland-Hopland Airport in Cleveland, Ohio. Value of the plant is \$149,687,000.

Operating cost for Fiscal 1962 was \$18,835,000, a figure which was budgeted to increase to \$48,450,000 for this year's operation. Construction program last year cost \$1,040,000; this year's construction program is \$4,494,000.

Lewis staff growth continued, with an increase budgeted for this fiscal year. Last year, authorized staff was 3,264; this year's figure is 3,983.



LEWIS RESEARCH CENTER scientists build a column-fused ion engine in a vacuum chamber, left, to study operating characteristics of electron-propulsion engines in space. At right, a plasma jet accelerator is operated in a ball pit rig.

Advanced Space Engines Evolve At Lewis

Cleveland—Bowl of large turbojets and the bowl of manjits have been replaced at the Lewis Research Center by the scintillating thrust production of electric rockets in high-vacuum tanks.

The research team that was responsible for pioneering work in turbojet afterburners, thrust reversers and noise suppressors, in transonic compressor design and the development of supersonic compressors and efficient turbojet engines, still directs its effort to the myriad problems of propulsion today.

But the problems and the powerplants now are different. Even the names of the buildings have changed, although in one case the acronyms have stayed. What used to be the Engine Propeller Research Building in 1942 is the Electrical Propulsion Research Building in 1962.

The old atomic wind tunnel has been turned into a large space chamber, 40 ft. by 180 ft., which has been pumped down to 10⁻⁶ atm. of mercury pressure. Engineers are looking at the larger surface openings of the old thrust, where they say they can put a 40 ft. by 180 ft. chamber with a double wall and a stainless steel base, and go to even lower vacuums.

The manojut has had seen Lewis participation in a number of projects still classified as propulsion research, but with applications far above the highest altitudes that the researchers devised of a decade ago.

The stabilization and control system for Mercury capsules was a Lewis responsibility as a subsystem manager. High-energy data technology—specifically for super stages of such vehicles as Centaur and Saturn—has Elmer the scientist at this Center. Electric propulsion methods and developments have joined the chemical rocket work.

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•**Electrothermal rocket**, which uses an electrical heating system, such as an arc or a resistance heater, to heat a gaseous propellant. The test of the cycle is convenient—the heated gas is accelerated by means of a conventional nozzle to get the thrust. Specific impulse of this class of engines gives up to about 1,200 sec. Examples of this type are the Aerojet and the Aerojet rocket.

•**Electrostatic rocket**, which uses an electrostatic field to accelerate a plasma—an ionized gas mixture of electrons and ions—to produce useful thrust. Specific impulse values range upward from the 1,200 sec. of the electrothermal rocket.

•**Electrostatic rocket**, which uses an electrostatic field to accelerate ions to produce thrust. In this type, deuterium ions also be injected into the exhaust to neutralize the charge and produce useful thrust. Specific impulse is on the order of several thousand seconds. Status of these engines is developmental as well as of the electrothermal type, and because of their high specific impulse values, they demand more attention as the deep-space mission area than the rocket electrothermal type.

Conceptually, the major portion of the work of Lewis' electrical propulsion group, the largest in the country, is centered on the various subtypes of the electrostatic engine even though it maintains an interest in the other types.

First of the electrostatic engines is fly-on the SERT (Space Electric Rocket Test) represents what is the electron beam-driven ion engine conceived by

Lewis' Harold R. Krohn. This engine grew out of a research project aimed at finding an efficient source of ion beam electric rockets. Lowest power consumption for ionizing atoms comes either from electron bombardment or electron ionization arc. In the latter, being used also by Hughes and Eldec-Optical in their electric rocket design—the propellant atoms are ionized by contact with burning chemicals. In the electron bombardment arc, the stream of propellant are forced to collide with electrons generated produced by electric arcs and held by strong magnetic fields in a spiral path to increase the possibility of collisions.

Krohn found that he could produce ions efficiently without electric arcs and with a low magnetic field strength. The inert mercury vapor propellant, fed into an ionizer chamber where an electron current filament heated the electron for collisions. A magnetic field was maintained around the chamber, the electron field to attach to a part of the chamber wall. The field is a slightly higher electrical potential than the design needed to accelerate. The ion beam started to move toward a grid and as further accelerated by a difference in potential between the grid and the accelerating electrodes at the end of the ionizer chamber.

Total energy used is the sum of the power required to heat and accelerate the ionizing electron and to maintain the magnetic field. NASA says that 33% of the mercury stream are stored at a specific impulse of 5,100 sec.

Second sub-type of electrostatic engine is essentially a Kaufman electric rocket which is being designed to use heavy molecules—possibly some day with molecular weights as the three-to-six in place of the microsecond propellant. Such an engine is being built for preliminary testing now.

Cathodic particles made up of many molecules have been proposed in contrast to the large atoms of cesium and xenon, that have characterized electric rocket propellant up to now. Production of these particles within narrow size limits is one of the major problems with this type of engine. But Lewis' Carl T. Nguyen devised a scheme for generating cathodic particles from aqueous chloride or alkali chloride vapors by running them through a solution and then a magnetic nozzle to condense on the particles. Analysis has shown that the particle size is held within very narrow limits and that there is a high degree of conversion of the vapor to particles.

This cathodic particle engine is considered as the third sub-type of the electrostatic rocket and is believed to have great potential.

Kaufman's engine has been tested at

Lewis to establish compatibility with the power supply, to check the long-duration performance, and to general to get it ready for the SERT flight. Part of the rocket test is to find out about electrostatic rocket engine operation in space, particularly whether or not the ion current can be maintained by the action of electron.

Beyond this flight test, two full-scale engines are being developed for tests in the Lewis vacuum facility. These full-scale engines will include most of the system to make the tests as realistic as possible.

One engine is an array of 10 electrostatic engines developed at Lewis, and will draw about five kilowatts of power. The other is an array of 12 Kaufman engines drawing 30 kw—the power rating of the SERT engine.

Theoretical Work

Beyond the experimental development and test of these powerplants is a large amount of work on theoretical and experimental work aimed at improved science for electrical propulsion. One combines a heavy ionizable electric rocket with a radioisotope generator. By using a battery-type structure for a space vehicle incorporating this method, NASA scientists believe the installed weight of the powerplant could be brought down as low as half a pound per kilowatt, and make 10 day trips to Mars possible.

Major work in the design of powerplants for space-age propulsion systems has been what happens to the fuel

under conditions of zero gravity. Theoretically, surface tension is the only surface force left in the absence of buoyancy, and the fuel should flow itself into a neat sphere. What happens in practice may be exactly the same or completely different, depending on the circumstances.

For some time, Lewis researchers have been studying fluid behavior in a microgravity environment using the facility available in a drop tower and rocket flights.

The aircraft is an ex-Navy North American A-1J, whose tank has been converted into an environmental laboratory for zero gravity. The tank is big enough to take a man plus a package of instruments. The experiments are conducted in a large Stratoscan block, as the package can be moved without disturbing either the experiment or the airplane.

The drop tower is a 100-ft-high facility which allows an experimental package to be dropped into a cushion. Energy-absorbing spacers take the brunt of the impact and make the package accelerate. Plans are under way to extend the drop capability by building a 400-ft tower complete underground some time after 1965.

Free-fall rockets have been fired for investigative tests of liquid nitrogen, and have more are needed for completion of the program. There will be fuel during 1965, the fourth was to have been fired before the end of June this year.

Later this summer an additional acro-



ION CYCLOTRON ionosphere approach used at Lewis to heat plasma to high temperatures.

gravity flight is scheduled in which a Lenva experiment will fly in a jigger back package as an Atlas.

The value of these model tests has manifested the profound dependence of a two-stage, self-propelled rocket for extended aerogravity tests. The vehicle will be able to handle a payload between 100 and 1,000 lb., about 30 in. in diameter, and will subject it to 5 to 10 g's of aerogravity operation.

On Lt. Col. Scott Carpenter's orbital Mercury flight, one experiment was a aerogravity test devised by Lenva. It consisted of a spherical container about five inches in diameter with a

one-inch diameter standpipe inside extending about one radius into the center of the sphere. A greenish fluid filled about one-quarter of the container. Purpose of the experiment was to see if the fuel stored in the standpipe during all the time of the aerogravity period. The application of this experiment is obvious: it was planned to get long-term data to object to as possible way of maintaining a constant fuel supply in a pump inlet.

All these experimental results show about the same thing: The fluid tries to pile on the slope for maximum wetted area. In the presence of a standpipe,

the equal between space is, of course, distorted by the geometry of the pipe. But the important thing is that the fluid continues to keep the standpipe wet so that as some form of failure occurs, there will always be fuel at the pump inlet when it is needed.

Materials Studies

One of the great areas for exploration lies in the metallurgy of the cryogenic temperatures and in the behavior of materials at these low values near absolute zero.

The application of this metallurgy will be largely to the tanks and lines of space vehicles using hydrogen propellant, either for chemical rockets such as Centaur, or for nuclear rockets such as Nerva. It starts with the problems of hydrogen embrittlement and runs out from there.

Hydrogen, being the smallest of the atoms, will diffuse through metals that are not impermeable. That was one of the problem areas in the Centaur. Liquid hydrogen diffused through the steel tankhead face of a ballhead separating the liquid hydrogen from the extremely "hot" liquid oxygen, and the resulting value of the tankhead degraded to nothing in the region of difference.

But the nucleus of hydrogen does more than diffuse through materials. It causes a phenomenon known as hydrogen embrittlement, in which the material gets more brittle because of the addition. One problem of Lenva metallurgists is to understand the embrittlement process and to see if anything can be done about it.

Cryogenic investigators change many of the customary and understood characteristics of materials to unknowns. The one of hyperelasticity is an example. Microscopically having a fine shield of steel or aluminum should go right through, leaving a pulchre, according to laboratory tests. In flight, particles shear out a hole and if the leakage can be handled—no zero brittle devices.

But cryogenic temperatures make materials extremely very sensitive to stress-strain. Material tests at Lenva and elsewhere showed that the low temperatures increased the notch sensitivity of metals. So a simple test was devised at Lenva to check what happens when a tail fin of cryogenic propellers is struck by a micrometeoroid.

There was no elaborate hyperelasticity aspect sought. The gas filled a standard 12-in. ball with an internal core, producing the relatively low-fat microstrain—elasticity of about 7,000 psi. The tank was a small unit with some liquid fuel. The result was a tremendous explosion and a shattered tank whose pieces



LEVEN ENGINEER studies spray characteristics for basic liquid design vehicle.

were like shrapnel. "Now," said one researcher, "what are we going to do?" Research programs are now under way and there is an extreme one under way here in the testing of all kinds of materials at all kinds of temperatures, up to all kinds of pressures. Then, in technology, in transport, in metal metals, dispersed metals, composites, structures, plastics.

At cryogenic temperatures, most conventional structural materials gain strength compared to their room temperature values; that they under a low in brittleness and in notch sensitivity. Tests to be here indicated that steel and steel is very good for cryogenic work, that titanium and glass fiber are outstandingly good.

So many of the Lenva scientific staff have come to their new area of interest from other than they possibly were the field of "rocketry." For example, the people who worked on compressors and turbines for turbopump engines 10 years back, have become concerned to the different, yet similar, job of pump nozzles, where the same problem of many-box can the operator learn he cannot without making one still in operation?

One of the big areas of effort is the Fluid System Components Division center on the design of cryogenic pumps. Two major philosophies govern the approach. First, maximum as to be for high work per stage, both in outflow and centrifugal flow, pumps. Second, try not trying to exploit the unique characteristics of the cryogenic fluids to operate in the existing regime.

It would be the way. Liquids accelerated through a pump experience local areas of reduced pressure, back at the back end of a pump supply lines. If the pressure falls below the pressure at which the liquid boils, it will flash to vapor. For some, the flashed vapor takes up 1,000 times the volume of the liquid, but for liquid hydrogen the vapor

is only 12 times that of the liquid. Liquid hydrogen, a pump can handle boiling hydrogen, but Lenva scientists have found it looks as if the same holds for liquid helium, also.

The trick is to add an radiator system of the kind together to get a small pressure rise without doing much work on the liquid. This pressure rise can be enough to recede into an vapor caused by evaporation.

One unusual phenomenon is being investigated to help test the problem of cavitation. By careful observation and measuring of a liquid, it can be placed under tension, just like a solid material and it enters the tendency to break apart. Liquids, of course, are themselves supposed to have no tensile strength; the experiments at Lenva have shown that specially prepared fluids do have some tensile strength in tension, and there is a possibility that it may come to be of some help in cavitation problems.

Laboration is an area where space environment adds a complicating factor. Most laboratories depend on an outside firm for the bearing surface; this is one to get in an because everything outside immediately upon exposure. But in space, there is none of this, in fact, liquid hydrogen is one of the best refrigerants of cooled systems in that environment. Lenva research is leaning toward pre-cooling of materials to provide laboratory tests.

The proportion of present and recent work is the least between components of a liquid propulsion system is a hard subject to understand unless you happen to use classical electron microscope line data. This striking discovery was made by Lenva scientists who were trying to find analytical solutions to the problems presented by shock waves in the flow such as might be caused by a right-angle bend. Some heads thought of electrical transducers (less in an analogy the theory was checked and it worked.

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Rover Status Report

Development progress of the Rover nuclear motor propulsion system hinges on good reactor data, which must be obtained this year if the first flight altitude of 1964 (1965) is to be met.

Several potential flight reactors have been designed, deriving on the development of the Rover-II series of non-flight reactors. First tests with Rover-II were completed with a certified power test last December. The Rover schedule calls for motor tests at the site of one every two months during this year, and selection of a flight reactor this year. If motor trouble develops during these scheduled tests, the flight schedule will be squeezed and probably delays will result.

Reactor test cell A, which is being converted to handle more Rover-II tests, was recently still in the process of checkout, with cold flow test scheduled for about a month ago.

There are large-scale problems with liquid hydrogen, in view where the technology is either weak or unknown. Unless these problems can be solved, and unless their solutions agree with assumed data, the program is in for some tough going. Typical examples of these problems include:

- Radiation effects on liquid hydrogen. Still unknown are the effects of neutron activation on the fundamental properties of hydrogen, and the effects of heating due to radiative transfer from the motor to hydrogen fuel in the stage vehicle stage tank.
- Heat transfer coefficients of hydrogen. Nozzle walls have been designed using assumed values for the heat transfer coefficient of gaseous hydrogen at extremely high temperature and low pressure. Test data is very meager, and the actual heat transfer could be 50 to 100% higher than the assumed value.
- Fundamental properties of liquid hydrogen. The effect of such thermodynamic properties as pressure and constant volume heat capacity, and heat of vaporization, are a dearth of data on such fundamental properties as viscosity.
- Dissociation effects. At high temperatures, the hydrogen molecule breaks into two hydrogen atoms. There is no data yet to indicate at what temperature this occurs, and what happens to heat transfer when it does.
- Behavior in a motor case. In the test engine, the liquid hydrogen gas through a phase change to prevent this before entering the motor case. If a ring of liquid hydrogen should get in the case through condensation, it would affect moderation of the fission process and therefore the design of the control system. Analysis indicates this should not happen, but the fact remains that the process has never been tested and said it is, the uncertainty remains.

clear. Rocket Development Station (NRSL) is managed by SNPO. The first three groups—Abercrombie, Cleveland, and Memphis and the development station—was directly responsible for all functions from planning to test of the Rover program.

Lowry Research Group, which is responsible for research and development of all kinds of propulsion and power systems for space, plays a supporting role in nuclear propulsion and power systems. Lowry, which reports to the Office of Advanced Research Program in NASA headquarters, works on projects agreed upon in that office and the SNPO. The Plans Board, Research Station, one of the Lewis staff operations, also supports the Rover program by test work, prepared for its reactor and in the operation of test stands whose primary tasks have directly in the development programs of components and systems for nuclear reactors.

Site Expenses

New facilities for engine and stage work have been requested for both the development station and Plans Board. Addition to existing structures also have been requested with the aim of building a completely integrated nuclear reactor development station.

clear motor area where work can start with motor assembly and go through the test loop of complete trials.

Looking at needed construction at the development station includes:

- Reactor maintenance, assembly and disassembly (MAD) building, provided by AEC.
- Reactor test cell A, used for all Rover reactor tests to date, not being modified. Original funding was from AEC.
- Reactor test cell C, now under construction.
- Engine test stand I, funded by AEC, and new motor construction to design by Acton Division, Aero-Gro/General Corp.
- Engine test stand 2, funded by NASA in fiscal 1962, now under design by Acton.
- Engine maintenance, assembly and disassembly building, partially funded in NASA's fiscal 1962 budget, now just starting to be built to design by Vays.

Most of the funds requested for expansion of the station in NASA's fiscal 1963 budget are for construction of facilities which extend the capability for handling complete engines and stages of the nuclear reactor. They will become

Nuclear Work Proceeds on Three Lines

Nuclear systems technology in NASA is advancing along three subjects aimed at propulsion and auxiliary power for advanced spacecraft of the 1970s.

Each approach—the nuclear reactor, the conversion of nuclear energy to electric power, and the application of that electric power to propulsion—starts with the energy in the nucleus of the atom.

Specifically, work being planned around these system concepts are expected to perform long-range, high-altitude missions for beyond the capabilities of man-powered chemical rockets. Application of these systems to the upper stages of advanced chemical rockets now under development should give a substantial payload increase for non-Earth missions.

NASA's work on nuclear systems takes three routes:

- Project Rover, the U.S. nuclear motor propulsion development program. This consists of three major projects: Kiva reactor, whose development is expected to lead to the design of a fissionable, Neva engine, first of the nuclear motor propulsion program; and Kirt, a high-temperature, gas turbine engine, which is being developed as a nuclear-powered, space stage vehicle.
- Nuclear-electric power conversion, now primarily in the form of the Stimp-10 (Stimp-10) development program, with additional feasibility studies of other advanced power levels. Goal of the Stimp-10 program is a power level delivering 50 kw. for about 70 lb. weight per kw. Ultimate goal of the power conversion program is to achieve figures of 10 lb. per kilowatt.
- Electric propulsion, now being studied in both system and component

forms. There are three general types of these engines: electrothermal, sometimes called the arc jet engine, electrostatic, generally called the ion engine, and electrodynamic, generally designated the plasma engine. Each type seems to have specific areas where its performance is an optimum. One expected result of NASA studies will be analysis, general and flight tests of these three different categories of engines to verify the performance claims made by their developers.

Joint Effort

Both these programs depend on the development of nuclear reactors for the basic energy source, much of that work currently is conducted as a joint effort by NASA and the Atomic Energy Commission. Electric propulsion is the exception here, its development is being done with conventional electric power sources which have several advantages for development programs, primarily their present availability. But application of these systems to space propulsion means that nuclear reactors will be the necessary energy source, and therefore at some future point these propulsion systems will be developed jointly by NASA and AEC just as the nuclear reactor is being managed today.

NASA and AEC operate within broad legislation which defines the general scope of each agency's responsibility. AEC is responsible for "...conducting, managing and financing research and development in the field of atomic energy, including the utilization of special nuclear material to generate useful energy." NASA's responsibilities involve "...conducting the aeronautical and space activities of the U.S. for peaceful purposes."

These broad definitions apply at the apex of NASA's nuclear system development. AEC does research and development on the nuclear reactor and NASA has the non-nuclear components and sub-systems, and the responsibility for integration of the reactor into space-oriented propulsion and power-generation systems.

Both agencies signed a memorandum of understanding Aug. 26, 1963, which organized a single project office for Rover management. By the terms of the agreement, the project office for this joint effort was named the Space Nuclear Project Office (SNPO) and Harold B. Singer was named as its main agent.

Finger holds two jobs. In addition to being SNPO Manager, he is also director of Nuclear Systems in NASA's Office of Advanced Research and Technology. His Deputy is an AEC man, Finger reports to the Director of the Office of Advanced Research and Technology in NASA, and the Director of the Division of Reactor Development, AEC.

Two extensions of the SNPO were also established to supply some of the management functions and technical liaison jobs. One of these is the Albuquerque (N. M.) Extension of SNPO (NPOAN), located near the AEC's Los Alamos Scientific Laboratory. The other is the Cleveland (O.) Extension of SNPO (SNPOC), attached to the Lewis Research Center for homekeeping purposes.

Both extension offices have the job of maintaining liaison with the newly formed office of AEC at NASA.

Each office also directs contractor work as assigned by SNPO.

The Los Alamos laboratory reports technically directly to the SNPO on its responsibilities to the Rover program. It is impossible for reactor and reactor component research and development and for launching nuclear reactors for Rover.

Test work for both reactors and engines will be done on the AEC's Nevada Test Site at Jackson Plains. This facility, recently designated as the Ne-



ENGINE TEST STAND No. 1 at Jackson Plains, Nev., designed by Aero-Gro/Acton Division, will be used for fast firing of Neva nuclear motor engine.

A complete line of antennas and antenna components



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[illegible]

This 20-ton self-loading antenna platform is used as a temporary test component and mounted on a steel bed frame. It is easy to assemble, and can be loaded by a crane or a hydraulic lifting device. When in transit, it surface panels become load supports, girders, etc., but completely at the top of the frame and can be highly sensitive in order to withstand transport over rough terrain. The platform has a large antenna assembly packed and sealed in foam (C) surrounded and self-washed (D) - mounted.

[illegible]

The *in vitro* model system for investigating the mechanism of action of the anti-HIV agent, zalcitabine (ddC), has been used to study the effect of this agent on the growth of HIV-1 in the presence of 1- β -D-glucosyl-2-acetamido-3,6-di-O-isopropylidene- α -D-glucopyranoside (1) and 2- β -D-glucosyl-3,6-di-O-isopropylidene- α -D-glucopyranoside (2). The results of these studies are discussed in the context of the mechanism of action of zalcitabine.



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part of an overall area referred to as stage static test and maintenance facilities, and they include:

- **Engine:** maintenance, assembly and disassembly leading addition
- **Stage assembly and maintenance:** activities for work on the KEF prototype of the Bussard program. Designed to run operating areas, only one line is returned routinely
- **Stages test position:** for fittings of the engine
- **Stage disassembly, maintenance and disassembly facility:** where the stages would go after test firing for overhaul.
- **Assembly and maintenance:** where the stages would be repaired and engine Bussard leading addition line
- **Radiation effects facility:** for development of flow components and estimation in operating configurations
- **Flow measurement:** to determine the flow, non-oxidative traits of components and systems
- **Support facilities:** including a test and test transferable units for carrying out the tests, a regenerative system, a power plant, extension of power lines and communications, and improvement of a communications facility, as well as a computer system for data processing and storage.

There are three related facilities requested in the Fiscal 1963 budget which are to be built at the Flushing station:

- **Space propulsion research facility**, for research on and testing of complete space electrical propulsion systems under simulated environmental conditions: \$25,675,000.
- **Nuclear rocket dynamics and control facility**, which is the addition and extension of facility B-1 at Plum Brook. This will be used to study the initial portion of the starting cycle when main

Hydrogen land transfer facility, to study the conversion of liquid hydrogen

under the rubric of the ancient society system. Nontile work will receive concentrated attention. Budget request, \$2.4 million.

Nuclear Rocket Development Station

Unlike other NASA centers and stations, this is a joint operation, with facilities shared by NASA and Atomic Energy Commission. NASA owns an land, and plant value has not been determined because much of it is under development. Actual location of site is at Jackson Flats, an AEC's Nevada Test Site. Last year's construction program was \$15 million this year, the figure is budgeted at \$40 million. Expected operating cost this fiscal year is \$2 million. A staff of 200 has been budgeted.

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SECONDS



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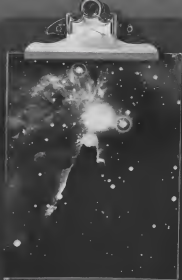
Current projects include the improvement and integration of existing systems . . . such as BMEWS, NORAD Combat Operations Center and SAGE . . . and the creation of even bigger, more advanced command and control systems.

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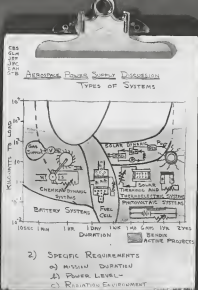
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boron, cryogenic and chemical dynamic systems; closed cycle bent engines.

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Aerospace Power Program



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Advanced Raytheon Sparrow III missile boosts striking power of the newest Navy jet fighter

An advanced version of the Sparrow III missile is being produced by Raytheon to improve even further the capabilities of one of the Navy's most effective defensive weapons. This new missile has greater range than its predecessor, operates at increased altitudes, and can be launched at higher speeds, against faster targets. It replaces the original Sparrow III missile and is the principal armament for the McDonnell F4E Phantom II, which is the nation's newest and most effec-

tive jet fighter plane.

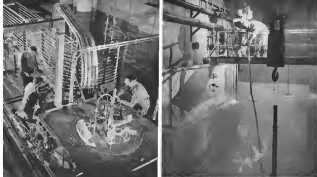
As with earlier systems, the improved Sparrow III employs a unique target seeker providing maximum attack flexibility to Navy pilots under operational conditions. Once locked on the target, this seeker guides the missile to the intercept, disengages, and returns, precisely relaying the aim so it closes with lethal accuracy on the enemy aircraft and destroys it.

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PLUM BROOK RESEARCH STATION technicians work at apparatus for testing simulated nuclear reactor hot elements, left. At right, tech means complete radioactive materials in canal leading from Plum Brook Research Reactor to hot laboratory.

Plum Brook Testing Advanced Propulsion

Suzhaky, Ohio—Dual testing capability for advanced space propulsion systems and components is taking shape at the Plum Brook Research Station near here.

One side of this capability is a nuclear reactor designed primarily for materials testing. It has a maximum power of 60 megawatts and a flux density on the order of 10^{14} neutrons/cm² per sec.

The other side is a rocket system test operation now building toward large-scale flow studies on complete upper stage, thrust and nuclear rocket systems.

Both groups of facilities are just getting started. The station has been operating for about six months. The reactor is currently licensed to run at 160 kilowatts, pending approval by the Atomic Energy Commission for full power runs. That permission is expected later this month.

Reactor hot units have been operating since last November in some programs, but the anticipated workload has yet to come and is waiting for completion of some facilities.

Staff doubled during the last fiscal year, from 200 to 400, reflecting the rapid building of the station to an initial operational status. Further staff increase has been requested by NASA and \$40 million of new facilities has been planned and requested.

Administratively, Plum Brook Research Station is a staff function of the

Lewis Research Center. The station director, A. D. Johnson, reports to Lewis director Abe Silverstein. Functionally, the station performs test operations, accepting research projects from Lewis, its contractors and subcontractors.

Nuclear Reactor

The Plum Brook reactor can be thought of as a cube with holes in it. Experiments are placed in these holes, exposed to the radiation flux of the reactor, and then removed for study or testing.

The reactor core containing the holes is about a 10-in. cube. Surrounding it are a vessel containing primary cooling water, a secondary cooling water tank for quench, four quadrant-shaped tanks for experiment access, three million gallons of processed water and up to nine feet of special concrete, which weighs about 210 pounds per cubic foot. Topping it are three 20-ton steel shields to keep the heat of the maximum credible accident—an explosion, equal to that of

about 400 lb of TNT. Housing all this is a 100-ft. dia steel containment vessel, designed to take whatever overpressure is left after the three steel ribs have borne the brunt of the explosion.

Around the quadrant there is a canal system, through it, experiments can be moved under water for maximum shielding.

A row of hot laboratories stretches off as a target, its duck-walled ribs braced only by lead glass windows, separated by oil films and nearly five feet thick. Behind these windows, protected from the radiation in the cell, stand the operators of remote loads and instruments.

After handling even more the water and air processing plant. Neither can be moved outside the plant unless they meet AEC maximum requirements for contamination. Thus, the cooling water goes to "hot" atomization tanks, where much of the radioactivity settles out, then passes to the "cold" tanks for further processing before being dumped into Plum Brook.

An filter the reactor containment dome is mounted in a bldg. tank, and it is only when the is exhausted through a 100-ft. high stack. There is an atm. safeguard—150 ft. weather tower continuously measures and records the temperatures at heights of 10,

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75 and 150 lb., to detect any possible temperature invasion that would not permit exhaust air to dissipate normally.

There are six primary tests in the reactor where experiments can be made:

• **HB-1, for solid-film element test.** The simple experiment will consist of a steel ball, rolling on a circular steel disk which has been lubricated with a film of solid-hydrogen dihydride. The object is to check the characteristics of the lubricant under exposure and compare them with the known characteristics without reduction change.

• **HB-2, for automatic samples at cryogenic temperatures.** Stainless steel, aluminum and titanium alloy samples will be subjected to a thermal reaction, duration of about 4×10^{-4} and a hot flux of 2×10^{-4} while being cooled by gaseous helium. In cryogenic temperatures. There is some belief that radiation damage may be greater at low than at high temperatures. These experiments are being devised to check that hypothesis which, hopefully, is wrong. This work is part of a contract study between NASA and Lockheed Aircraft Corp.

• **HB-3 and HB-4, for studies in large nuclear physics, especially in studies of mesons.**

• **HB-5, for hydrogen-pressure materials.** Experiments here will be subjected to the highest level of thermal reaction—54 x 10^{-4} of which the reactor is capable. Purpose of the experiments will be to induce samples of materials at high temperatures and check them for radiation damage.

• **HB-7, for Neura actuator experiment.**

This test will consist of checking a prototype actuator developed for the Neura engine system under radiation comparable to its proposed circumstances. The test will be cyclic while under test so it would be in the real engine.

All these experiments will be subjected to the 10-day full-power cycle of reactor operation except for the Lockheed cryogenic tests, which will be conducted for one hour.

Naval cycle of the reactor will follow the 30-day "on" period with a 5 day shutdown, before resuming full-power operations again.

Primary job of the rocket motors division here is to make operational tests on high-energy, upper-stage propulsion systems. For that reason, their technology is weighted in the direction of hydrogen-oxygen and hydrogen-fluorine engines.

The range of test work covers the current raising of system components, such as a liquid fluorine pump, to future runs of the Neura stage through the first quarter of its starting cycle.

To do this large variety of activities, the station has activated as a working on these test facilities.

• **A. Prop tests at large flows.** Capability of this unit is about 100 lb./sec. of liquid hydrogen, although it can test after liquid propellants. Some checkout runs have already been made with liquid nitrogen, and a couple of tests have been made with liquid hydrogen.

• **B-1 Neura altitude test.** This test

stand is being applied for improved altitude capability for the Neura engine, will check the starting transient of the motor for about the first quarter—15 sec, or so—of the start. These tests which have to be non-machining in nature, will be run with a standard reactor.

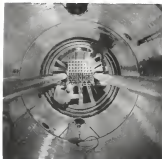
• **B-2 Apollo lunar landing module test.** This test is being applied for simulated runs of the Apollo lunar landing module.

• **C. Turbopumps for liquid hydrogen and liquid oxygen.** This unit has a flow capability of about 100 lb./sec. It is presently running with two liquid-hydrogen pump rigs, one of them is a long-shaft type with low net positive suction, the other is a straight pump for inlet studies.

• **D. Turbine research.** This stand is a double one which can handle two components simultaneously. It has several demonstrations about the power from the turbines, and can handle up to 15,000 hp. There are three demonstrations, rated at 5,000 hp, each. Currently this stand is being calibrated and checked.

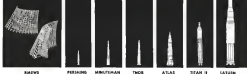
• **E. Dynamite tests.** This huge apparatus, originally planned to shake toxic gases, instead instead somewhat bigger than the Atlas, stands 120 ft. high. Electro-magnetic shakers are installed, and it is possible to simulate burning by dumping propellants at a programmed rate. But the stand was never used for this purpose, and is now being studied to fit the Apollo support mission.

• **F. Helium bleed test.** In this test, both cryogenic and non-cryogenic sys-



OVERHEAD VIEW of Titan thrust reactor may lose its primary test, left. But a 25 ft. below building's guide level. At right, 100 ft.-dia reactor containment vessel. Turbopumps support huge "double" for combining combustion experiments.





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test components can be studied over a wide range of conditions up to high flow rates and high pressures.

•**G: Pilot bulbs.** In this earth-based test site, the first to operate here is rocket system test, small pumps and turbines are being run to get design data for other facilities.

•**H: Control control and instrumentation.** This building is the common control of all stands except R and J, which have their own control and instrumentation. All operational tests are controlled from panels in this building, and the data measured at the site is recorded here.

•**I: Fluorine pump stand.** This test apparatus was developed specifically for testing liquid fluorine pumps with flow rates about 30 lb/sec. It has two test cells. First of these was a Lewis-designed pump, the second was a custom design.

•**J-1: Heat transfer stand.** This apparatus burns hydrogen and oxygen to generate a high-temperature gas for flow nozzle studies. Nozzle is made of thick copper to measure temperatures after one second of burning at a very high heat flux.

•**J-2: Heat transfer stand.** This test stand was originally a low-pressure hydrogen fluoride test, but the test stand is now being modified for hydrogen-oxygen work.

•**J-3 and J-4: Advanced tank tests.** These stands will be used to study tank designs for liquid hydrogen fuel in terms of insulation problems and related heat-transfer work.

•**J-5: Fluorine hydraulics laboratory.** This stand originally did work on the hydraulic properties of liquid fluorine and is now inactive.

Plum Brook Research Station

Plum Brook Research Station, operated by Lewis Research Center, is located at the former Plum Brook Ordnance Works near Sandusky, Ohio.

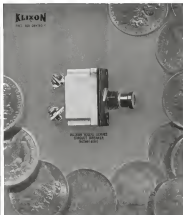
Total area occupied is 5,968 acres, of which 3,164 are occupied under permit from the U. S. Army, and the remaining 2,804 acres are in process of being transferred from Army jurisdiction to NASA.

Value of the plant is listed at \$18,114,800.

Upgrading cost for Fiscal 1962 was \$1,944,890, for the fiscal year, the agency asked for \$1,283,000 for operation.

Construction program budgeted for this year is \$95,243,000.

Staff was authorized at 490 for Fiscal 1962. NASA hopes to increase it to 515 this fiscal year.



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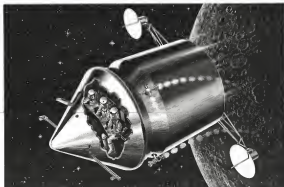
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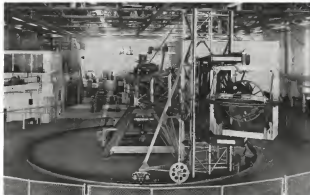
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FIVE-DEGREE-OF-FREEDOM mechanism at Ames is one of a number of advanced testing devices being installed at the center.

Ames Generates Basic, Applied Knowledge

Research goals advance greatly in both physical and life sciences; entry physics is chief study effort.

Moffett Field, Calif.—Critical need of basic and applied research knowledge needed for the mastering technologies of space and advanced aeronautics is being presented at Ames Research Center here for use by National Aeronautics and Space Administration, the military services, other government agencies, and industry.

In this job, Ames has singled out research goals far beyond those it sought during its outstanding contributions as a key part of the predecessor National Advisory Committee for Aeronautics.

Ames' broad effort, oriented heavily toward basic research, falls into two general categories—the physical and the life sciences. Physical science research is an umbrella-like activity, totaling about 92% of the center's effort and divided into four general areas—entry and environmental physics (45%), aerodynamics (35%), guidance, control and navigation (20%) and space research (2%). Half of the work in physical sciences is performed for NASA's Office of Advanced Research and Technology at headquarters.

Life sciences, a relatively new activity comprising about 8% of the Ames research, has been assigned the responsibility for advanced research and technology in this vital field for NASA. Most of its work will be performed for the Advanced Research Office and the Office of Space Sciences at headquarters.

The physical sciences are organized under five main divisions—vehicle construction, aerodynamics/aerodynamics, fluid static and systems research, entry and wind tunnel, and instrumentation. An indication of the capability of the Ames facilities is that the entry and wind tunnel divisions are assigned a substantial share of the aerodynamic studies

that were being conducted at the USAF's Arnold Air Development Center at Tullahoma, Tenn., when the main wind tunnel there was rendered inoperable. The Instrumentation Division at Ames presently is a supporting organization for the center.

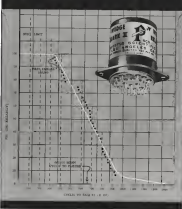
Life sciences work is divided among three divisions—biology, environmental biology and biotechnology.

Despite this organization by division, each having a number of branches to further achievement, Ames strengths are not compartmentalized by specific channels of research. Key to the effectiveness in sustaining the flow of information in the broad areas in which the center works is organizational flexibility.

This allows cutting across divisional and branch lines for coordination of research teams and for transferring resources to related efforts when a promising line of study shows up as a "byproduct" of another study.

An example of this flexibility is the Mission Analysis Group operating under the Vehicle Environment Division, with a complement of scientists drawn from many branches. This group now

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Ground Winds Studies

Madley Field, Gold-Edwards of ground winds on booster and payload combinations are being investigated at Ames Research Center for both National Aeronautics and Space Administration and the Air Force, encompassing launch site conditions at both the Pacific and Atlantic coastal ranges. These open coastal studies have been performed at the 12 ft pressure tunnel with 1/10th to 1/12th scale models, with velocities of wind speeds as great as 40 mph.

General evaluation of the studies is for a that the effects of ground winds do not load themselves to any theoretical analysis. Certain combinations of payload and ambient towers can severely reduce the wind speeds that a vehicle can withstand.

But the supposition is that more modifications can attenuate these effects. Work in this problem area is expected to be completed in a few months and result in a recommended approach, which will draw on some detailed knowledge of flow phenomena that has been accumulated thus far.

in evaluating the feasibility of methods for carrying out high performance space missions that may be required perhaps 10 years in the future.

This type of activity is considered essential to Ames' own research efforts and to general support of NASA's progress, because Ames' management feels the center has the talent to evaluate what the state of the art will be able to support in the future. Investigations by this group include missions involving the Apollo spacecraft, support phases of lunar landing and fall-back scenarios to Mars.

Personnel strength at Ames at the end of FY1961 was 1,497, which is equal to 1,611 by the end of March 1962. By the end of last month the crew was scheduled to have increased



COMPUTER before (top) and after photograph shows performance of photos in re-entry. Ames experiment produced best load of 20,000 lb. velocity of 15,000 mph.

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As a non-Belgian and American, my introduction of American design at the 1958 Brussels Congress was

to 1.675. At the end of Fiscal 1963, personnel strength is reported to reach approximately 2,090—an increase of 175 over Fiscal 1962.

The center occupies 215 acres of land. Plant value-including office buildings, shops, hangers, flight simulators, classrooms, specialized wind tunnels, hypersonic test ranges, and other installations-is estimated at approximately \$125 million. Operating cost of the center was approximately \$71.5 million for Fiscal 1962 and is expected to be approximately \$28.1 million for Fiscal 1963.

Cost of construction program for Fiscal 1962 was estimated at \$6.1 million. The proposed program for Fiscal 1963 is approximately \$84.4 million and includes:

• Much 30 billion tunnel, which will afford detailed information such as load distribution and large movements not obtainable over the next 100

single in any other installation. The tunnel is expected to produce research results which will be applicable to the Apollo spacecraft design engineering design and construction phase.

The tunnel will be a blowdown type with a 48-in.-dia. cast-iron, later changeable, needles will provide Mach numbers of 30 and 50 at Reynolds numbers in the span of 0.3 million to 1.4 million. Test compressive 50-sec runs will be possible before refilling the system, which will require three hours and have a 5,000-gps. pressure capitolity. Facility's maximum compressive capability will be 1,000F.

- Radiative heat systems for the main transfer facilities, which will prevent runs with unattainable inputs and radiative and convective heating. The system will allow use of 6-in.-dia. pipes, considered to be the smallest practical

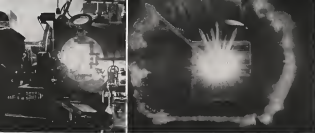
heat in this type of testing, and will allow evaluation of heat shield sections consisting of the ablating layer, insulating layer, and the backbone structure.

Shoppers agree that Apollo will be the last generation to enter, which they will not have to face significant combinations of inflation and corrective tax loads. This new look is all far more basic data in connection with future vehicles.

- Space flight guidance research facility, which will permit simulation during the takeoff, midcourse trajectory, entry and landing phases of the environment, acceleration, deceleration, rotation, and specific tasks of astronauts in a realistic space capsule

• **BioScience Laboratory** for systemic and substrate research and studies in immunology, genetics, microbiology and parasitology. Advances in these fields will be explored both in-house and by contract.

[illegible]



COMBINED radiative-convective heat simulated in Ames shock tube (left). Projectile fins generated at 34,000 mph, impact at right.

Ames Examines Re-entry Heat Problems

Moffett Field, Calif.—Broad spectrum of convective and radiative heat problems associated with the re-entry flow lanes and planetary flight is being analyzed both experimentally and theoretically at the Ames Research Center, spurred by the necessity for data that will guarantee the safety of the Apollo manned lunar missions.

Varied effects of convective and radiative heating and the results of interplay between the two are complicated by many factors, including vehicle speed, face and afterbody configurations, materials, ablation phenomena, ionization in the gas cap, and other environmental factors.

In the process leading to convective heating, the gas in front of the entering body is ionized as it passes through the shock wave, and forms a hot gas cap. The portion of the cap adjacent to the body usually forms a boundary layer flowing around the vehicle. Part of the energy in the boundary layer is transferred to the body by the nature of the fluid itself, and this phenomenon is called convective heating.

The reflux of high-energy gas particles in the hot gas cap area that

energy states. As these energy states fall to lower levels, the excess energy is emitted as electromagnetic waves.

Much of the energy in the shock wave is therefore transmitted directly to the vehicle in the form of radiative heating.

Apollo Heating Problems

The first fraction of heating of the three-man Apollo spacecraft will result from convective and the heat shield has been designed specifically to cope with that. But an appreciable heat contribution—enough to be considered

serious but not doubling—will come from radiative heating, and is appreciable amount of the Apollo heat shield weight will be used to deal with it.

In the earth-orbit regime at the 16,000 fpm possible speed (speed with which the spacecraft approaches the earth without an additional impulse), the blunt shape tends to minimize convective heating whereas the pointed shape minimizes the radiative heating pulse. Frequently, therefore, the shape of the entry vehicle will be the result of compromise.

For high-thrust parabolic speeds that are desirable for skimming trip time—43,000 fpm, for example—radiative heating becomes the primary cause of aerodynamic heating. At speeds sufficiently high, it is expected to dictate vehicle configurations.

For reentry with radiative heating as predominant, Ames researchers believe it will be necessary to employ sweepback—reduce the vehicle's local

surface so that it is not perpendicular to the wind direction—is opposed to the flat, almost straightaway face of the Mercury spacecraft or a horizontal nose re-entry body. The angle of attack could be the Apollo for re-entry affords the desired sweepback for its speed regime.

In planetary modes, where entry speeds of 40,000-50,000 fpm can be anticipated and where a single ballistic trajectory would seem to be preferred to eliminate the need for elaborate control systems and attitude positioning, the required sweepback of the vehicle fins may be achieved by using pointed noses to entry bodies. Degree of sweepback would be defined by the included angle of the cone.

Current Studies

Such bodies, on the basis of theoretical studies now being made by Ames researchers H. Julian and Alvin Senti, appear to be optimum from the standpoint of minimizing the total heating (convective plus radiative).

A test-field reduction in the radiative component is achieved by going from a 45-deg half-angle to 30-deg half-angle, for example. By comparison, the angle associated with the Apollo flight attitude would be about 60 deg. At this angle, the radiative component would be about three times as great as for the 45-deg half-angle case.

Shapes appreciably more slender than the Apollo configurations are being investigated in connection with a series of planetary missions. Experimental studies to determine configurations suitable for a Mars entry capsule for the Mariner II mission are being conducted as part of an overall study of planetary entry problems.

Design logic, to be applied in precision parabolic entry speeds, to balance the effects of convective and radiative heat may vary the geometry of the nose, possibly by slanting with a pointed cone configuration composed of different materials and allowing successive sec-



H2O2 and water flow on re-entry model studied at Ames. Velocity in test was 51,500 fpm.

tions of the cone, from the nose back, to be obtained. This would produce an increasingly blunter face as ablation progressed, until entry speed begins to be slowed mechanically.

Heat transfer resulting from air ionization is being studied closely to determine how thin plasma-sheath effects convective heating, because considerable ionospheric events on its appearance. An ionization leads to increased, ionospheric field, when radiative heat transfer is present as an aggravating factor. Charge exchange cross-section studies also are being conducted because of their relevance to ionization heating, and numerical measurements are made of the tendency of the charged particles to surrender their charge to the neutral gas molecules.

Radiative Heating Identification

Another problem relating to radiative heating is the need to determine what part of the spectrum is causing the energy. Although temperatures of the hot gas cap may be in order of several thousand, with most of the radiant energy probably being emitted in the ultraviolet range, the relationship of vehicle velocity to radiative heat transfer has not yet been defined with any degree of certainty. Studies indicate the dependence of radiative transfer on velocity ranges from the fifth power to the 16th power of velocity and possibly even higher.

To determine necessity of radiation as a function of wave lengths up to speeds of 45,000 fpm—sub-orbital at the others from a Martian mission—free

flight models are being studied with photo and filter pickups.

Many materials have been tested under combined heat loads comparable to those which Apollo will experience. This testing again is concerned not only with relative characteristics of the material but with the thermal properties at well-delineated ionization levels for a given weight of material.

So far, this testing has been limited to an impulsive heating cycle, in which maximum heat flux is imposed and held constant for a time before termination. The time span is less than that to which Apollo would be subjected, but good combined radiative-convective heating rates are obtained and give some understanding of Apollo conditions. The tests are considered valid because the aim is to show which materials are promising. Materials studied have included phenolic resins, low-temperature aluminas, and thermal aluminas.

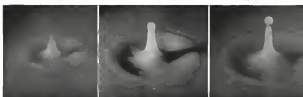
Theoretical studies are being conducted on the total mechanisms of changing materials—the development of the char, the manner in which it recedes, and the controlling factor determining the rate of pyrolysis (breaking down of the base of the material into a burning front).

Wetted Heating

Radiative heating generated in the nose behind entering bodies is being investigated in a ground-based study. Apollo will have such an afterbody heating problem. Heating rate will be modest but application will be for a



PHOTOGRAPHIC SEQUENCE shows characteristics of drop of water impacting on a water surface in Ames Research Center study. This test



is part of a fundamental program to obtain data on the effects of materials heating on simulated planetary surfaces.

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A new concept in semiconductor reliability has evolved from Douglas Mission and Space Systems Division's and the National Aeronautics and Space Administration's determination to ensure 100% systems success in Delta space vehicles. This concept, termed **EHR** for Extreme High Reliability, is conceived at present with orbital and deep-space probes launched by the Douglas-built Delta. Texas Instruments engineers, working with NASA and Douglas personnel, beginning with a complete re-examination of current manufacturing philosophies... all the way through to helping establish the systems reliability standards. In essence, this program defines **EHR** as "building in quality in addition to testing for it." **EHR** had to be much more than just another testing program, for testing the finished product cannot guarantee the conditions under which it was made. To provide NASA and Douglas with "Space Quality" parts, Texas Instruments began its evaluation procedures by multiple 100% inspections during processing and 100% inspections by the independent Quality and Reliability Assurance department to assure creation of a device as nearly free from any flaw as is currently possible. **EHR** quality control procedures include microscopic inspection at each stage of manufacture beginning with materials and parts inspections before the assembly process is started. Assembly is performed in controlled atmosphere under positive pressure to help ensure the elimination of all foreign material. Even the jigs used to hold the devices throughout the assembly processes are subject to the same microscopic scrutiny as the devices they carry. These are just a few points in the **EHR** program, developed jointly by NASA, Douglas and Texas Instruments. A partial list of tests given **EHR** devices AFTER manufacture are listed below. ■ **Particle Detection** — This test checks for possible foreign material (internal wire

approved HIGH RELIABILITY



leads, solder balls, etc.) in the encapsulated unit. This method uses a vibration table set of 10 g's zero to peak in conjunction with a piezoelectric accelerometer, electrical filter and oscilloscope with the accelerometer mounted in a special fixture designed to hold it directly against the can. This test detects metallic contamination weighing in micrograms or greater. ■ **Coastal Acceleration** — The purpose of this test is to demonstrate the mechanical robustness of the device under all time but nondestructive conditions. Depending on the device, each transistor is tested in the Y₁ plane with a nonrotational acceleration of 5,000 to 35,000 g's applied to the device (nonsparking) for one minute. ■ **Operating Test** — Since the first 250 hours of device operation are the most critical, the "Power Burn In" test is performed on each unit to assure device stability. Each device is operated for a minimum of 250 hours at T_a = 25°C under full dissipation (P_D) condition. ■ **Creep Test** — This test is to determine if moisture is present within the encapsulated device. It is performed as the device temperature is varied from T_a = -80°C to 25°C under operating conditions. Continuity with respect to terminals must be observed at 100p. ■ **Vibration (Mechanical)** — This test establishes the device's electrical characteristics in an environment similar to that seen in actual missile system application stages. The device is subjected to vibration at 60 ± 5 cps at a minimum peak acceleration of 15 g's for a period of 30 seconds. During the test, the forward voltage vs. current characteristics are monitored for flutter, shift, discontinuity, ringing or other instability. ■ **High Temperature Test (non-sparking)** — This test is to determine the stability of the device electrically after elevated temperature conditions. The transistors are stored at an ambient temperature of 200°C ± 5°C for 250 hours minimum. ■ **X-RAY** — X-Ray is used to test for foreign particles and to

ensure uniformity of construction. ■ **EHR** is an all-out effort by Texas Instruments to achieve the long-sought goal of providing the Systems Designer with "Space Quality" parts (i.e., devices approaching 100% reliability). ■ You can give your circuits semi-conductor reliability far in excess of that previously available. You can specify devices produced under all of TI's **EHR** techniques or only those applicable to your specific military or industrial needs. ■ The manufacturing techniques and testing that comprise **EHR** result from TI's depth of technological skills, plus the determination and willingness to meet every TI customer's requirements. Today, more than ever before in service, reliability and experience, you can rely on TI.

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The basic concept of **EHR** is "building-in reliability in addition to testing for it." Shown above is an **EHR** transistor device at Texas Instruments. Each **EHR** device is subjected to repeated **EHR** acceptance inspections under positive pressure, controlled atmosphere by TI's independent Quality and Reliability Assurance department.

EHR was developed by Texas Instruments, working with Douglas Mission and Space Systems Division, prime contractor to NASA for the Delta space vehicle program. EHR helps ensure the success of programs such as the TITUS II, shown here launched by the NASA/Douglas Delta space vehicle.

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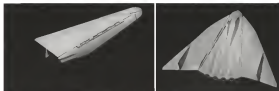
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VARIABLE GEOMETRY winged aircraft which is under actual test study at Ames Research Center. During test model at left shows one before configuration for cruise. After reaching the starboard, the wings would be rotated high for post landing control.



long time, creating a heat seal. Tests are conducted with rates of 10 to 100 lbs./sq. ft. to simulate, roughly, the shock conditions expected for Apollo. The tests are run in an air jet tunnel using a cylindrical model with the ablative material as an inert armor.

Because radiative heating is sensitive to gas surfaces, Ames is studying the surfaces believed to be representative of planetary atmospheres. The problem is aggravated by the variance in emissivity of atmospheric constituents. For example, carbon dioxide control for Venus has been obtained to be anywhere from 10 to 90%.

One of the key facilities at Ames which has worked in major contributions to the general study of radiative heat transfer from the shock wave in the hypersonic free flight wind tunnel, which has been in operation about one year and is an outgrowth of the super sonic free flight facilities that have been operating at Ames for about 15 years. It is devoted primarily to the study of heating problems which Apollo will encounter.

Information is obtained on the radiative power emitted per cubic centimeter of gas behind a shock wave sweeping at speeds up to about 40,000 ft./sec. These speeds are obtained from

the facility's combination of a shock tunnel and light gas gun. The facility's capability is expected to be raised to 70,000 ft./sec.

Both the equilibrium and nonequilibrium aspects of radiative heating phenomena are being studied. It has been found that equilibrium radiative quantities can be determined for one situation on the basis of existing theory. Nonequilibrium radiative heating phenomena are not understood as well and one problem is that of solving it is doubtful if Apollo has any serious nonequilibrium radiative heat problems.

Ames scientists are working on design specifications for two cases: hypersonic hypersonic free flight facilities. One will be devoted to the study of radiation and physics of high temperature air at up to the shock layer. It also will design a combination installation of shock tunnel and light gas gun for a capability of 70,000 ft./sec. It will permit the use of larger wind-tunnels to 1.5 in. in diameter as constrained to 0.5 in. diameter models used now—and broader ranges of atmospheric densities to allow detailed studies of nonequilibrium radiation phenomena. The facility will permit attachment of 10,000 psi stagnation pressure to allow the Reynolds number of entry to be equaled or exceeded.

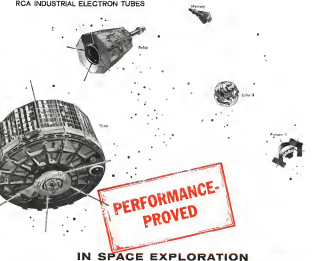
Hypersonic Behavior

Shock Field, Cold-Stability, and excited problems areas in which hypersonic behavior differs greatly from Newtonian flow phenomena have been revealed at the Ames Research Center's free flight tunnel at speeds above Mach 15. These phenomena have been observed.

- Failure of the bow shock wave to be swept sharply on the after part of blunt nose bodies.
- Generation of secondary flow fields in the hypersonic shock layer by slips or turbulent flows.

These efforts could cause the hypersonic stability and controllability of some entry vehicles such as the shuttle was based configurations to differ appreciably, even drastically from what was expected initially. Shock could cause instability, with consequent failure of the mission due to inadequate heat shielding in the resulting conditions, or structural loading.

In the case of secondary flow fields generated by slips, a theory has been derived which indicates that the pressures on slips and flows can range from one-tenth to three times that expected from Newtonian conditions, depending on the specific situation.



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Ames Aids Apollo Guidance Development

Mallett Field, Calif.—Development of the guidance system for the three-man Apollo spacecraft has channeled Ames Research Center's talents into a supporting function for the Massachusetts Institute of Technology, which has the responsibility for design and development of a prototype system.

Ames research is focused on the midcourse and earth-entry guidance phases of Apollo's flight to the moon and back. The midcourse navigation technique now is fairly firm and has been developed on the ground by mathematicians. The technique is based on Ames-developed principles stemming from work begun about two years ago, and growing out of experience in similar problems in aircraft flight.

Guidance procedures adopted in an indirect manner regarding on-board computer representation. It will use an IBM 7090 digital unit and is known as the reference trajectory technique, which anticipates the use of a total velocity correction of about 100 fps. This is relatively small, considering the spacecraft injection speed into its escape trajectory of approximately 36,000 fps.

For computation on the ground given the present trajectory, based on four-body equations of motion that take into account the effects of gravitational fields of the earth, moon and sun on the vehicle's motion.

Celestial Observations

The midcourse navigation system takes over after the spacecraft is injected into the chosen trajectory for the particular launch time. The celestial observations on which the system is based consist of measuring the angle between a navigational star and the line (tangent) of the earth, or between another navigational star and the line of the moon.

In this procedure, the small on-board digital computer calculates what the angle should be between these reference points if the spacecraft were on the proper trajectory. Then, an observation of the same star and line of the earth (or moon) is taken with a sextant (not hand-held) and the variance from the computed angle is obtained.

Degree of Deviation

On the basis of this difference, the computer calculates the degree of deviation from the reference trajectory. The procedure is repeated perhaps 10 or 12 times at half-hour intervals after the first hour of the trip. Based on these variance differences, the computer performs a mathematical smoothing process which calculates the most probable position of the vehicle in space, a point which is more reliable than depending upon a single reading.

Another program in the computer takes this position information and produces the pre-calculated mid-course from the starting point at the moon, which may vary from 10 to 100 mi. moon

altitude, depending on the specific hour of arrival.

This total procedure is repeated possibly once more during the trajectory and again just before the pre-selected end-point or end-point is reached. After each endpoint calculation, the computer determines the required velocity correction to establish a new trajectory to hit the end-point, based on a minimum expenditure of fuel for the correcting propulsion system. It also computes the time determination when the correction thrust should be applied and determines precisely how to re-align the vehicle with altitude just by specifying slope to rise and for what duration. In the case of application of this ad-

justed trajectory technique, the mid-course guidance system never attempts to retain the vehicle to the reference trajectory but attempts to make it meet the trajectory at end-point.

Return from the moon would use the same midcourse guidance technique, but for the earth-entry trajectory, Ames is examining an alternative scheme to the one being prepared by MIT. The basic concept of the Ames approach is to enter the "Chapman entry corridor," which varies in depth for every entry vehicle, depending upon its maximum 140 drag coefficient and rate of weight to drag coefficient. For the Apollo vehicle, this corridor depth is 35 mi. for a 140 maximum loss on the structure.

Space Window

In effect, the technique establishes a window in space that the midcourse trajectory must hit. If the vehicle enters below (undershoots) the lower boundary, the thrust will be increased, although it is still possible to enter for earth return. If the vehicle comes in appreciably over (overshoots) the top boundary, it will continue on around



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SCHLIEREN photograph shows performance of the Apollo nozzle with a Ray contour at the center of the fluid flow. Ames Research Center tested this model before the Apollo configuration was set. Tests were made with the tip control shown at the lower limit extent and with an offset to the center of gravity.

the earth along the same parabolic trajectory which is used for approach to the earth.

Finest Path Control

For the flight to earth from the Chapman corridor, Ames is pursuing the following two schemes to control the path:

- **Regulative position technique:** Can refutable pilot navigation work for back drive with this technique, and if such can be made possible.
- **Based on present position velocity, and acceleration of the vehicle, a high-speed digital com-**

OSO Instruments

Navstar Field Cold-Experimented perage on the Orling Solo Observer for visible course instrumentation developed by Ames Research Center to define the lifetime of temperature control systems for spacecraft. Six different examples—low profile and two thin film—can be used to determine the specific line characteristics of each.

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para-net likely to be available in the time span required for Apollo would obsolete the ingenuity the vehicle would deliver and the point on the earth where it would land. This computer, too, would be performed repeatedly all along the path, and as the instrument flew the vehicle according to a display, he would correct it accordingly, with computer outputs to view the flying value and roll angle to achieve the desired landing point. Each time the astronaut made a control correction, the computer would calculate his new trajectory and the display would change accordingly.

• **Reference trajectory technique.** This is similar to the automatic guidance technique in many respects depending upon precomputed reference trajectory data stored in the on-board computer. It would not require the speed and complexity of the computer employed for the corrective correction technique and therefore would be available in the Apollo development time-span. This technique also is being considered for laboratory checkout.

Each system, when fully developed, is expected to allow a landing accuracy area on earth that is roughly elliptical, with a major axis of approximately 5,000 mi. and a minor axis of about 2,000 mi. Both systems are expected to be applicable to follow-on vehicles beyond Apollo.

Lunar Surface Conditions

Moist Field, Cold—Close to lunar surface conditions that will facilitate the design of spacecraft landing systems and needs for lunar mobile vehicles are being provided in hyperbaric impact studies by the Aeronautics Research Center, in cooperation with U.S. Geological Survey.

The studies are conducted to explore the mechanism of meteoroidal impact and the resulting physical phenomena. Two test materials have been chosen as representative of the lunar surface—lead in the underlying contrast between soft and hard for surface testing material. Conclusions drawn from test data is considered so far indicate these general lunar conditions:

- Atmosphere of dust coats with a typical density of 10⁻¹² from greater than the submicron range down through the dust by impact. This indicates that there is a thin layer of loose, fine powder material on the lunar surface.
- Lunar surface also is covered with a general pattern of fractures and cracks as seen from nearest to large angular blocks.
- Spray from crater formed by impact at oblique angles will be systematically toward the crater, instead of in the general direction of the trajectory of impact.



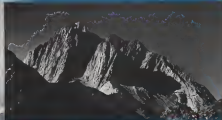
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TABLE
TOP

There is only one way to compare the way the solar simulator replicates the sun's radiation to the way the sun's radiation actually strikes the earth's surface. This type of testing is expensive and time-consuming, and even the most sophisticated equipment at the top of the tallest mountain. The sun's spectral emission is strongly filtered. Recently, solar simulators have come into use. OCL's making use of its extensive experience in the design and production of multilayer interference filters, has built a unique and revolutionary solar simulator. Instead of using absorption or water filters which gradually deteriorate and require constant replacement problems, OCL's design included stable all-dielectric filters. Consequently, OCL's simulator requires only 1 KW power input, illuminates an area of 20 sq. m. simulates with full sun intensity, and perfectly matches Johnson's curve in spectral output. OCL's progress with filters and systems instrumentation now makes it possible for the scientist or engineer to duplicate, on the mountaintop table top, the sun's emission as it would be at the edge of the Earth's atmosphere. (With no need for climbing boots.)



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RYAN VZ-2 deflated blimp V/STOL form with thrust axis deflected 35 deg. to improve longitudinal pitch characteristics.

Ames Studies V/STOLs, Mach 2 Transport

Moffett Field, Calif.—Aerodynamic research at the Ames Research Center is exploring two important advanced configurations—V/STOL aircraft for commercial and military operations and the supersonic transport for the next generation of international passenger flight.

V/STOL research is investigating the feasibility of a vehicle to serve as an aircraft carrier, in keeping with government thinking on methods to improve the nation's transportation system.

Ames' philosophy is that V/STOL aircraft in general will be operating most of the time in STOL configuration. The center's approach to this situation is to extend the helicopter's ability to capitalize on the good high hovering efficiency of rotating aircraft and increasing its cruising speed capability.

The specific approach is to use a rotating rotor concept. Previous flight studies involving the Bell XV-3 Convertiplane disclosed that this approach was feasible except for rotor stability problems in high-speed flight. The XV-3 has good hovering characteristics, low down-draft velocities, and good turn characteristics at low speed. Ames' approach is to improve rotor stability to extend operation into the relatively high-speed region of 200-250 kt.

Rotor modifications have been made to the XV-3 and the aircraft will be tested in the Ames 40 x 80 ft tunnel and in flight. If these modifications—

increasing the Tip-to-Tip value (tip-path coupling ratio) to as high as 45 deg, and the addition of restraint springs to the rotor system—are successful, Ames will consider extension of XV-3 performance to configurations of a tail rotor engine to explore possible problems at higher speeds. But this turbo-propeller XV-3 would require support of the military services for a comprehensive operational test and development program.

Reverse Approach

Another approach to the interest in reverse configuration reverses the basic conditions of the XV-3 by starting with a good forward speed capability and designing a good vertical capability into the configuration. This scheme involves modification of conventional-type aircraft in reverse steps to reduce the approach speeds and, as a consequence, the landing area requirements. First step is to improve the lifting system of the flap and increase the thrust weight

ratio of the engine. Some progress in this direction has been made with the BLC (Canadian, later converted) version of the Lockheed C-130B Jet Assault and the Douglas F-4J deflated blimp approach plane.

The BLC version of the C-130B cuts the landing distance of the conventional C-130 by half, but tests have disclosed that landing qualities—control, stability and steep approach capability—must be improved for operational use.

Ames researchers are examining the potential of the BLC version with the use of a piloted landing approach simulation to determine which aerodynamic parameters require improvement and to what extent stability and steering augmentation will be required.

Simulator tests so far have indicated areas of modification. Incorporation of specific changes into the aircraft and flight tests are the next steps being considered. Target is to obtain landing speeds of the order of 18 kt and landing distances of the order of 500 ft. This would be unusual low-speed performance for an aircraft of this size—120,000 lb gross weight—which ordinarily uses an approach speed of about 110 kt, coupled with a landing roll of 1,700-4,500 ft.

Next step with this configuration would be to improve wing lift and co-

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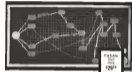
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crease thrust/weight ratio. This would require more sophisticated controls, for example, the use of propeller pitch for lateral control, which might require shifting instrumentation of propeller to eliminate asymmetry in line speeds.

A second step for further improvement in takeoff and landing performance would be to provide a flipped lift wing with provision for flapless coverage of the entire span. This effort is aimed at ultimately obtaining a very efficient capability—possibly in a small test and development period of about three to five years.

Successful development would permit a much larger, gross weight V-STOL aircraft than the tri-service transport, which is projected for flight in 1955 but probably will not be operational until 1965. Ames will be performing simulation studies and 40 to 80 ft. wind tunnel tests of the tri-service configurations. It is likely that this work and the studies on the BLC version of the C-130B will produce data for repeated improvement of both.

Ryen, Bell Vehicles

Flight tests of the Ryan VSC-100, a three-engine configuration are under way at Ames to examine the stability and control problems in the low speed regime.

Ames also has been using the Bell X-14A in its V-STOL studies. The aircraft replicates the delta-wing principle. This aircraft, which has been fitted at Ames with two General Electric J65-F engines to increase performance and supply sufficient air for the reaction nozzles, also has been modified to include variable stability and control features. This configuration is expected to provide:

- Exploration of possible problem areas of a specific V-STOL design before it would be flown.
- Derivation of acceptable control characteristics applicable to any V-STOL aircraft.
- Opportunity to evaluate applicability of the X-14 principle in low landing studies. Following is that the jet lift and reaction-control concept generally is similar to that envisaged for lunar landers.

As now configured, a possible program would consist of a trajectory study angled with an investigation of control characteristics. The trajectory study would include an approach to touchdown from an altitude of 5,000 ft., in both vertical and non-vertical trajectories.

Time and fuel involved in descending from a given altitude to a point on the ground would be of interest, assuming that vertical velocity judgment would be left entirely to the pilot. Second phase of the study would consider the effect of the control dis-

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LOCKHEED HC-130B with blowtype boundary layer control on wing and tail surfaces is tested at Ames. Tests with tapered system indicate increased performance gains with flap deflection beyond 70 deg., need for stability augmentation.

activities (usually impedance damping) on the ability to carry out the approach and landing.

Because the thrust required for level in the lower atmosphere would be considerably reduced, the achievement of a given horizontal acceleration for a given mass would require that the thrust vector be tilted farther in the lower atmosphere, compared with the requirement near the earth.

The aerodynamic characteristics peculiar to a winged vehicle such as the X-14A could be eliminated in the tests by the suitable stability and

control features incorporated in the aircraft.

Supersonic Transport

Supersonic transport research at Ames is part of a coordinated NASA-in-house effort, mainly in aerodynamics and structures, being done with Federal Aviation Agency funding under the first FMA/NASA-Definitive Department program. Research here is concerned with preliminary identification of critical characteristics of various configurations.

Phase objective of the present program

is to assess sufficient information by mid-1965 that the three agencies will be able to make a recommendation on the advisability of further government support for supersonic transport development, based on both financial and technical considerations.

Feasibility of the supersonic transport for flight at Mach 3 has been established. Research now is directed at defining components and integrating these into a transport configuration which would be a money-earning machine capable of safe operation.

Although the supersonic transport



FILE XV-3 in tests of effect of large flapping hinge deflection angles and spring springs on dynamic stability at high speeds.

New lithium developments at Foote Mineral offer new boost to aerospace programs

The properties of lithium metal and lithium compounds have long received considerable attention in the field of aerospace technology. However, serious problems, including handling, containment and corrosion resistant at high temperatures, have deterred its broad use. Now, with assistance from new technological developments at Fluor Mineral Company, it is possible to use the unique properties of lithium metal and lithium hydride in many areas of aerospace technology, propulsion, heat shielding and nuclear heat shielding. Some of the typical uses, and the available lithium compounds, are listed below.

First in importance is the development of a lithium metal of unprecipitated purity, 99.99% pure. Because Fort has successfully reduced nitrogen in the metal to less than 40 ppm, corrosion is markedly lessened and the metal has been safely contained and circulated at temperatures as high as 360°C. With use of refractory metals, to special alloys in container walls, corrosion is

higher temperatures, up to the boiling point of lithium (1030°F), may be achieved in the future.

Second, problems relating to delivery of metal without contamination have been essentially solved. Now, new handling techniques mean the purity from production through utilization. Forty-one supply high-purity lithium in special containers—or will fill your container, from which it can be transferred, melted but uncontaminated, to your system. We also offer special metal products of high-purity lithium. For example, machined shapes, wire, strip, rod, sheet, ingots, diborides.

A third major area is the development of many other types of lithium compounds of value to aerospace programs. For example, lithium hydride, also produced in high-purity form at Fosi, because of its excellent heat of fusion and vaporization properties, pure lithium hydride is of value as a heat sink and coolant in nuclear reac-

reactant and its low density are important in radiation shielding, while its chemical properties find applications in fuel cell design. Sodium lithium hydride produces high specific impulse when used with oxygen oxidant, it is a candidate for use in non-propellant systems. Little is known, however, from an application standpoint when it comes directly with caustics under many conditions.

Our research and development programs embrace the applications listed in the chart below. If one of these areas is of special interest to you, please contact us. We will very likely be able to assist you. And you will also find these technical data bulletins of interest. A letterhead request will bring these to you. Bulletin 101, Lithium Metal; Bulletin 102, Lithium Hydroxide; Bulletin 118, High-purity Lithium Metal. People Minerals Company, Department 022, Route 100, Exton, Pennsylvania.

originally was projected as a March 5 intercontinental, 3,900-watt air conditioning, Acme engineers now feel that data obtained from these guidelines were established point to initial operation at lower speeds—perhaps March 2 or slightly better—and even shorter, or contractual time-frame.

This would permit earlier operations, possibly using intrinsia engines which would be modifications of existing powerplants. This approach also would furnish some flight experience toward the Mach 3 capabilities, and a Mach 2 transport could be used for operation in mid- or perhaps 1968-to meet foreign requirements.

The Mach 3 transport begins to approach the limit of reasonable benefit with regard to time saved at high speeds considering the flight ranges involved. Time spent on cruise becomes so small that the increased cruise speed would result in little reduction of overall flight time.

Engine, Stability Problems

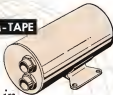
One major technical problem in the investigation at Ames has been development of an engine or inlet to provide the airflow required over a wide range of altitudes and flight speeds with a minimum penalty to the plane's drag characteristics. The problem boils down to a stringent matching comparison between inlet capability and engine demands.

Because basic aerodynamic damping of the supersonic transport will be less than that of its subsonic counterpart, some type of stability augmentation will be required. Ames researchers have established the aerodynamic damping lock through wind tunnel tests of supersonic transport models and that has provided data for the simulator program (AW Aug 36, p 52) in which Ames has investigated the problem a pilot would encounter in controlling the aircraft, both with and without stability augmentation.

Other critical factors are landing approach and take-down speeds. It's generally agreed that these will not be allowed to exceed those of the present subsonic jet transports, but the aim of the researchers is to reduce these speed ratios for the supersonic transport, if possible. Guidelines have been that the transport would have to operate, all things lengths of existing major jet tri-

To study the loading speed problem, Ames researchers have been conducting tests in the 40 x 80 ft wind tunnel of representative configurations, to develop low-speed, high-lift capabilities. Preliminary results have been encouraging, indicating that it will be possible to hold landing speeds at the level to the order required—about 140-145 kt.

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Ames Advances Life Sciences Lead Time

Moffett Field, Calif.—Life Sciences Research Laboratory at Ames Research Center has responsibility for the major effort in this type of work for National Aeronautics and Space Administration. Goal is to develop a degree of competence in the life sciences, so that data generated through its research will be ready at least five years ahead of progress which require this new knowledge.

Laboratory activities will span the fields of ecobiology, environmental biology (including physiological and behavioral sciences, and biotechnology), which will be the realistic function of crossover between biological and physical sciences.

One indication of the practical application of the laboratory's work will be in its responsibility for the "manned portion" of the guidance and control function and displays for the Apollo spacecraft. This manned portion includes analysis of physiological (performance), physiological (biomechanics, system stress), and neural aspects of the astronaut. Stress tolerance studies at Ames already have produced a technique for detecting physiological and psychological changes in man before they can be determined by his performance. This includes the ability for recovering a reliable test of viscoelasticity, which is one of the first biochemical tests to respond in a stress situation.

Research Program

Laboratory now is performing in-depth program to lead to development of selection and training criteria for succeeding groups of astronauts.

In the end of this year, the laboratory will have doubled its staff from a strength of about 50 to approximately 100 members. Although this might be considered a considerable slow building, considering the extent of scientific investigations, the expansion of personnel has been pragmatic solely on a basis of need.

Plan is to maximize the responsibilities for life science research in NASA in three ways:

- Build an in-house research capability in areas not presently covered in the U.S. national effort.
- Transfer life science research, on a task basis, to the three major services and other government agencies on the basis of what each is capable of performing.
- Utilize, through research contracts and grants, the entire national capability in universities, industry and research institutions. Through this medium, especially with universities, NASA hopes to stimulate education in space-related areas. About 90 grants and research contracts already have been issued to universities and other research organizations.

Major in-house effort for the next

year which is of specific interest to NASA.

Thus, for the past two summers, NASA life sciences activity has been centered on a billion flight program to study the biological effects of heavy cosmic pressures. This summer, five missions will be flown, each carrying about 500 lb of experiments suspended from the balloon. The flights will be the longest (56 hr.) at the program altitude (117,000 ft.) and latitude. Launch will be from Goose Bay, Labrador, and recovery is anticipated on the Pacific coast north of Edmonton (Alberta). Primary experiment will be exposure of man to heavy cosmic pressures, with the lion in the tight for investigation. The animals will be monitored physiologically. Other experiments on these flights will include microbiological specimens for study of genetic evolution, biophysical in transformation for the measurement of the components of the radiation spectrum. Universities and government agencies will conduct these experiments jointly.

Ames has submitted to NASA headquarters a development plan for carrying out accomplishable biological ex-

Life Sciences at Ames

Life Sciences Laboratory, a relatively new activity of Ames Research Center, is progressing to perform studies and experiments to develop data for overall use in NASA in the following scientific regimes:

Ecobiology

- Life on other planets
- Life synthesis
- Molecular biology
- Instrumentation for search and identification of extra-terrestrial life

Environmental Biology

- Effects of environments on earth organisms
- Ecology
- Bio and organic chemistry
- Bacteriology, virology, and immunology
- Zoology, botany
- Biological rhythms and performance
- Genetics

Physiological and Behavioral Sciences

- Manned space flight research
- Performance and utilization potential of man
- General physiology
- Experimental pathology, endocrinology, neurology, psychology
- Bio-mechanics research

Biotechnology

- Non-mechanical integration
- Life support, personal equipment, crew accommodation, nourishment, oxygen and temperature control, radioactive protection, waste disposal
- Utilization of man, selection, training, integration, control, monitoring, maintenance, scientific observation.

* Work will be conducted under Environmental Biology

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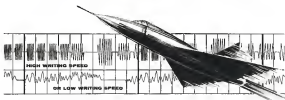


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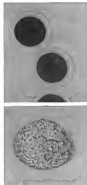


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periments. This would require an Atlas Agena boost vehicle for low earth orbits at 7 to 14 days duration. The experiments are designed to be both integrated so as to understand the complex effects of space environment on the biological system—essential for a sound manned space program. While the experiments have been approved by NASA, the spacecraft has not yet been approved. Two spacecraft are planned for the program. A changeover is the first choice for the scientists, but if weight becomes a critical factor, they will be utilized.

Although the Ames life sciences group is not charged with compliance in life support systems, the group will develop the capability to the extent that it will be able to exercise responsibility for the integration of relevant data from industry, Air Force and Navy into the total manned system. Under this responsibility, Ames will send contractors for life support systems, monitor development of the prototypes and presently evaluate all life support data for industry and aviation service use.

Air Force and Navy have promised to Ames to conduct liaison with the Life Sciences Laboratory and NASA will facilitate coordination of information.



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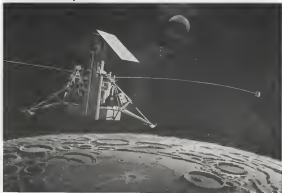
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Flight Research Center



Flight Research Spans Velocity Spectrum

Edwards, Calif.—Aerodynamic investigation of piloted aircraft at the National Aeronautics and Space Administration's Flight Research Center continues both ends of the speed spectrum, from the hypersonic rocket-powered X-15 to the powerless propeller, which so far has reached a maximum speed of 55 mph.

By far the bulk of the talent, energy and money expended here goes to support the X-15 project which is managed by NASA, although 80% of the project's funds are provided by the Air Force. Since the first powered flight of an X-15 by North American Aviation test pilot Scott Crossfield on Nov. 15, 1960, the three testflights have been carried aloft by a modified Boeing B-52 bomber nearly 100 times and have made more than 50 powered flights.

The performance envelope of the aircraft has been stretched to Mach 6.64 and to an altitude of 747,600 ft—man's fastest and highest flights in a fully controllable vehicle.

Still greater feats are in store for the X-15, and although NASA will not say

how high or how fast future flights will be, wind tunnel models of the aircraft have been tested to Mach 7 and no official estimates put the maximum altitude at 300,000 ft. (AW Nov. 20, p. 32).

Flights for the sake of exploring the

beliefs of the machine itself probably will be completed early in 1965 but the program has been so successful that 55 follow-on flights have been scheduled.

In addition to the basic research objectives—aerodynamic testing, operational and control problems, parachuted data on pilots, hypersonic aerodynamics and structures and exit and reentry investigations—the follow-on program will use the X-15 as a platform for other engineering and scientific studies. It spans a payload cost of \$100,000, the remarkable X-15 is cheaper to use than some of the unmanned probes that might perform the same tasks. Experiments will include altimeter, stellar photographs, tests on a business compass to develop an attitude control system, use of an alpha-beta connection pipe for

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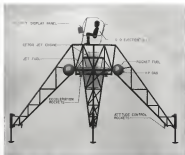


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SKETCH of the free flight test loading simulator placed by Flight Research Center. Pilot capsule actually will hold one man, and later will be enlarged to accommodate two.

fact, the Center has been accused of running a hobby shop because of the amateurish appearance of the craft.

The Pegasus now operating in the test and model component here. The first was a model of the aircraft because of the pilot's unfamiliarity with the technique required when being towed by another aircraft. A simple remote was used by checking the prospective paraglider pilot out in a tugboat's wake, with little doing the extracting. A couple of hours' instruction from Bilek, who has won numerous trophies here and showed us his 23 years of soaring in a helio, proved to be sufficient to teach the technique.

The present Pegasus is a refinement over the first, chiefly from the control system standpoint. It is maneuvered by shaking the center of gravity of the whole machine through four cables linked to a control stick. Boulder pilots are provided that, some only to steer the nose wheel. Research pilot M. O. Thompson says the rubber pilots who were in hands lost only in the air and admit that he finds himself "nearly sinking" the rubber pilots when serious inputs out of hand begin.

Wing of the paraglider is formed by three spans bared to make a delta with 45-deg. sweep. The airtail is made from 6 or 8-in. Dacron formed into a delta with 55-deg. sweep. The cross surface is the tail which it so follow in flight, giving the aircraft the proper aerodynamic characteristics. The glider weighs 640 lb., including pilot Thompson and his wing loading of 435 psi. For

back of a specific category under which to license the craft, NASA obtained a Federal Aviation Agency experimental certificate, just as would someone with a home-built aircraft. Since there is no test or loading on which a license might be granted, a special plate sporting the number N9799C was attached to the wing support strut.

Cautious Expectations

On typical test flights, the Pegasus has been towed to 5,000 ft. by a Piper Super Cub, northeast pilot—from a local airport. The slowest high drag configuration of the paraglider makes this quite a chore for the Super Cub, and a more powerful tow plane is being sought. So far, no great amount of maneuvering has been attempted with the Pegasus, and experience of its characteristics is proceeding cautiously. Despite its simple appearance and the subtle problems given by the Pegasus wing support, the little craft has some rather lively flying qualities.

At a forward speed of 35 ft./sec, the stall rate is 1,300 ft./sec. On wing (the same dimensions for both speeds), a forward speed of 60 ft./sec. produces a stall rate of 25 ft./sec., a performance far more than that of a jet fighter with a dead engine. Lift drag ratio is about 3.0, compared with 3.5 for the X-15.

The paraglider does not exhibit stability characteristics similar to those of an aircraft. A pull force is required on the stick to maintain a constant air speed if the airtail is either increased

or decreased from the trim point. In a more conventional aircraft, one expects to apply a push force when flying faster than trim speed and a pull force if flying slower. Thompson also points out that very little energy is available for forward on landing. The wing then at a high angle of attack and obviously produces a lot of induced drag which, coupled with the flexible and parasitic drag of the cockpit, causes the speed to bleed off rapidly when the altitude is increased for landing descent.

Program Pushed

Despite flying difficulties, the test program is being pushed because of the obvious uses of the Pegasus wing in supersonic and booster recovery applications. First an operational use of a Pegasus wing will be for landing the two-man Gemini capsule.

Once the test program here has been pushed far enough to establish the basic drag qualities of the paraglider, the next step will be to secure the wing support struts and make it a true Pegasus wing. The only screening problem will be how to keep the wing from tilting on the pilot after landing.

Licensed from the Parkway will be applied by the Flight Research Center in forthcoming tests of a suborbital glider being built by North American Aviation for possible application to both the Gemini and the three-man Apollo capsule.

Future projects include an extensive test program to explore problems of operating supersonic transports, for which it is expected that the Pegasus will be added to the Center's inventory. At the same time that NASA is conducting no maneuvers to determine control system requirements, FAA personnel will be involved in obtaining data for Air Traffic Control and certification criteria.

Chances are that such early testing in defining a stall speed. Even today, FAA criteria regarding stall speed is applied to winged aircraft in a steep-wing aircraft, stall speed is generally well below the lowest usable speed, and the latter is not adequately defined. What rather this means is the Pegasus wing has been far more landing and takeoff performance than NASA will develop considerable time to correctly define stall speed and minimum useful speed in the 35 ft./sec. range.

Bilek and he also expects that NASA will let a contract in response to the normal proposals that have been submitted on a supersonic transport diversion issue later Lockheed and North American are among the companies that have proposed the use of a Subsonic or JetStar that could be equipped with flight control systems designed to duplicate the flying characteristics of any number of different supersonic transport designs.

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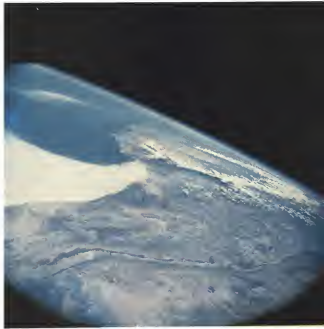
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NASA's Relay (left) and Bell Spitzer's Telstar, scheduled for launch this year, are part of broad communications satellite program.

NASA Plans to Expand Comsat Program

Greenbelt, Md.—National Aeronautics and Space Administration will initiate two new active communications satellite projects this year—one as an intermediate altitude (32,000 mi.) vehicle and the other an advanced synchronous orbit satellite, if present plans are approved by the Administrator and Congress authorizes the funding.

The new projects, together with the present Relay, Syncom and Telstar satellites scheduled for initial launch in the coming year, are complementary pieces of a NASA program to resolve technical unknowns and to develop the technology that will enable a commercial comsat to implement an operational system of medium-term effectiveness at minimum cost.

Defense Department is working closely with NASA on the Syncom project, a lightweight, limited channel satellite to be launched into a synchronous, near-circular 22,380 mi. high orbit as the forerunner of an advanced satellite intended to be placed in a synchronous (geostationary) orbit.

The NASA communications satellite program is expected to play a more prominent role in active communications than contemplated earlier as a result of the realignment of Defense Department's own Project Advent communications satellite.

In recent testimony before the House Committee on Science and Astronautics, Assistant Secretary of Defense John H. Rubel said that Syncom, being developed by Hughes Aircraft Co. under NASA contract, will permit evaluation of a number of simplified control techniques.

If this pans out, "the probability exists that it might be more economical to put several of these relatively smaller and simpler satellites in orbit to accomplish a given communication capacity and function than to use the larger type of satellite currently planned under the Advent program," Rubel said.

Multi-Satellite Program

NASA is exploring its research and development efforts in passive communications satellites, with emphasis on satellite structures, multiple satellite launching with a single booster and passive attitude stabilization, according to Leonard Jaffe, director of communications systems in the Office of Applications at NASA headquarters.

In the Fiscal 1963 budget submitted to Congress, NASA requested \$15,777,000 for its communications satellite

- program, with funding as follows:
 - Project Relay—\$18,341,000
 - Project Syncom—\$4,067,000
 - Intermediate altitude satellite (new)—\$25,595,000
 - Advanced synchronous satellite (new)—\$18,681,000
 - Project Reliance (passive satellite)—\$16,747,000
 - Project Echo (passive satellite)—\$115,000
 - Advanced research—\$2,688,000
 - Advanced technical development—\$2,373,000

The first six projects, which involve launching operations, include the cost of booster. Project Telstar is not included in the list because American Telephone & Telegraph Co. is continuing its construction, cost and will reimburse NASA for launch costs.

The Relay and Syncom satellites, which NASA is launching, and the Telstar, funded by the Bell System, are designed to explore a number of the present unknowns with a certain element of operational swing.

The communications satellite program is directed by Goddard Space Flight Center and is directed by Robert Black in the Spacecraft Systems and Projects Division, headed by Daniel Marmor.

- Project Telstar, presently scheduled to be the first launched with an objec-

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One of the methods for achieving reliability in Honeywell Rate Gyros and Linear Accelerometers has been concentration on simplicity in design. Components with fewer parts and reduced friction for more reliable operation have been the result. These instruments have a record of proven performance in flight control, rate stabilization, attitude control and rate damping.



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Honeywell Designs Complete Gyro Overhaul Facility for MAAGA



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RESEARCH AND DEVELOPMENT NEWS



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tive of achieving an apogee of approximately 3,000 mi and a perigee of 900 mi, will weigh about 170 lb and provide bandwidth for transmitting one television channel in 600 one-way video channels. It will transmit at a frequency of 4,170 mc, with an output power of about 28 watts, and receive at 6,590 mc. The Titan also employs a spin-stabilized antenna; therefore, the doughnut-shaped antenna pattern produced by its quadratically mounted antenna will illuminate the earth only for a portion of each orbit.

• **Project Relay**, being built by Radio Corp. of America, is scheduled for launch that fall into an orbit similar to Telstar. The 16-lb, topshaped satellite will carry four transmitters, in-service, redundancy means, examined sensors and decoders, providing look up service. Each satellite transmitter receiver will have a bandwidth capable of handling one TV channel. Relay will transmit at a frequency of 4,170 mc, with an output power of 10 watts, four times the power of Telstar, and it will receive on a frequency of 3,735 mc.

This will permit comparison between Relay and Telstar to evaluate the different operating frequencies and adjusted power levels. Relay, like Telstar, will be spin-stabilized to its doughnut-shaped antenna pattern will illuminate the earth only during a portion of each orbit. Relay will be equipped with a magnetic attitude control system, similar to that pioneered by RCA on the Tera technological satellite, which can produce small changes in vehicle attitude through interaction with the terrestrial magnetic field.

• **Project Sponoon**, slated for launch early next year, is expected to weigh about 50 lb, not including the weight of the balloon mount attached to look at into orbit when it reaches 23,000 mi altitude. It will be the first U.S. attempt to put a satellite into orbit at the altitude, while only carry 10- or 50-mil thick protective covering to cushion its launch. Sponoon, Relay project manager at Goddard.

NASA hopes to obtain more comprehensive data on space satellite from its upcoming scientific satellite S-58, and from the Defense Department's Arcturion satellite, originally scheduled for launch by a Centaur.

Other Research Areas

To develop improved techniques required to implement a communications satellite system, NASA is expanding its research and advanced development in the following areas:

- **Attitude Stabilization**—Major improvement can be achieved if extremely simple and reliable techniques can be devised for keeping the satellite's antenna or its antenna pattern constant.

tion will always be directed toward the earth-orbiting Relay and Telstar. If the Hughes technique proves out, it will open the way to providing highly accurate earth-to-earth antenna radiation patterns without complex antenna stabilization systems. Success will carry dual transmitter receivers and will transmit at 4,315 mc, with an output power of about 33 watts, and receive at 7,350 mc. This will provide a third set of frequencies whose spin performance can be evaluated.

Radiation Experiments

To obtain data on the effects of space radiation on payload performance and lifetime, both the Telstar and Relay satellites will carry modest radiation experimentation equipment. Success will not be so assured because of payload weight limits.

Telstar will carry four silicon diodes designed to measure proton at various energy levels between approximately 100 and 50 million electron volts (mev), and electrons with energy levels of 0.25 to 1 mev.

Additionally, Telstar will mount three solar cells, each with a different amount of shielding, whose output will be transmitted back to earth. Also, an silicon transistor, specially fabricated with a wide base region to make them extremely sensitive to radiation damage, will be mounted on the skin in pairs, each pair shielded by a different amount. Their output also will be transmitted in comparison with a accurate transistor which has been protected from its sensitivity, according to Charles P. Smith, Telstar project manager at Goddard.

The Relay satellite will carry an even more sophisticated radiation experiment, including four proton sensors, two electron sensors, 27 silicon solar cells and three gallium arsenide solar cells.

Some of the solar cells will be unshielded, while others will carry 10- or 50-mil thick protective covering to cushion its launch. Sponoon, Relay project manager at Goddard.

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only directed toward the earth. NASA is employing techniques that do not require the use of expendable fuel to secure long life in orbit. Earth-orbiting stabilization provides more effective use of satellite transmitter power by permitting the use of direct and antennas. It also permits use of smaller antennas and lower-power transmission in terrestrial stations.

• **Higher gas antenna**—When earth-orbiting stabilization can be accomplished, antennas with higher gas can be used. In terrestrial applications, increased gas usually is accomplished by increasing the size of the antenna. In this approach, power problems for space vehicles because of payload size limitations. One promising technique for a satellite antenna with a gas of 15 db and no moving mechanical parts, currently under development by Hughes Aircraft, was recently reported at the National Aerospace Electronics Conference in Dayton (AW June 11, p. 88).

• **Improved modulation techniques**—As the payload weight becomes more and more important, different types of modulation techniques may prove useful. The choice also depends upon whether the bandwidth required is narrow or wide. NASA hopes to conduct relay-able experiments in a satellite to evaluate the relative performance of a variety of techniques, such as pulse coding and single subcarrier.

• **Improved power sources**—Dependable, long-life electric power sources still are a much-sought objective, according to JPL. While often in NASA are responsible for developing advanced spacecraft power technology, the communications satellite group is sponsoring development of improved solar cells and a investigating radioisotope power packages for possible use in communications satellites, according to JPL.

Passive Satellites

The future role of passive communications satellites largely depends upon whether a simple, reliable technique can be devised for attitude stabilization to earth orientation of large, amorphous configurations, JPL believes. An additional need is the development of techniques for fabricating virtually large, reliable, unorthodox structures capable of maintaining their structural integrity for extended periods in space.

NASA recently awarded a contract to General Dynamics/Convair to conduct a preliminary study of gravity gradient stabilization of a passive satellite which might be shaped like an inverted umbrella. The study seeks to determine whether gravity gradient stabilization would be strongly dis-

tributed by solar winds and infrared pressure.

In the search for lighter weight in Earth structures, NASA is sponsoring programs of G. L. Schuchman Co. and Convair Corp. of America's Vroom Division. Schuchman has developed a three-layered balloon structure in which the outer most foil layer is photoetched to form a honeycomb-shaped pattern which reduces overall weight by about 50 percent without significant loss of structural strength, according to Herbert Ecker, who heads Convair's passive satellite program. A somewhat similar result has been achieved by Convair's Corp., using an expandable mesh foil which is covered in a stretch of Mylar or polypropylene.

Project Rebound

Goldstar Research currently are studying the needs of a Douglas Aircraft Co. study of the feasibility of multiple passive satellites launched from a single booster, known as Project Rebound.

An Apollo-type vehicle would serve as the carrier vehicle, its three inflatable satellites, each housed in a container equipped with three solid rockets and with a retrograde rocket and associated controls. The carrier and payload, each weighing about 1,000 lb., would be launched into an elliptical orbit with an apogee of about 1,500 mi. Upon reaching apogee, the carrier vehicle would be spin-stabilized.

The three inflated satellites should add an approximately equal speed in a circular orbit. But this requires precise control of carrier vehicle attitude and the instant of ejection of the carrier.

NASA hopes to make another attempt to make a 135 ft. dia. Echo 2 satellite, at altitude, this summer, as a prelude to placing the large return of Echo 1 in orbit later this year. The satellite, launched from a Titan II, now tests will be equipped with a new type of tracking beacon, which will also telemeter back data on the balloon's skin temperature. A more advanced beacon, intended to determine both skin temperature and pressure, under development by Aero Gen Acme Corp., is planned for use on the orbital Echo 2. The company also is redesigning the beacon, which is powered by solar cells, to respond in electronic signal output for use at higher altitudes, Ecker said.

A considerable number of ground stations in the U.S. and abroad are expected to participate in the forthcoming active communication satellite tests. The large AT&T facility at Andover, Mass. (AW Apr. 16, p. 160), has been modified for use both with Echo and other older Echo terminals will be located at Plouzanet-Bodley, France,

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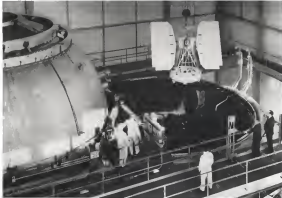
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HAUSAU meteorological satellite prototype is placed in 39 in. vacuum chamber at General Electric for qualification tests.

Weather Satellite System Due by 1965-66

Greenbelt, Md.—National Aeronautics and Space Administration hopes to launch next spring its first Nimbus weather satellite, prototype for a satellite-based operational system that is expected to bring the entire world's weather under regular and frequent surveillance by 1965-66.

National Operational Meteorological Satellite System is being developed for use by the U.S. Weather Bureau in a joint agency effort. But the system could well become an international one in its ultimate use. Other potential users, such as the Defense Department and Federal Aviation Agency, make their needs known through a coordinating committee.

With a Nimbus satellite in a circular, near-polar orbit at 330,000 mi. altitude, the Weather Bureau should obtain two pictures of weather conditions over even spots on the earth every 24 hr., one a television picture made during daylight hours and the other a cloud-cover map made by infrared observation. Present plans call for launch of the first Nimbus at approximately noon so that its pictures will be taken at local noon and midnight over each location throughout the orbit.

To detect the birth and development of thunderstorms and tornadoes, which have much longer lifetimes, more frequent observations would be needed. This could be accomplished by placing more Nimbus satellites in orbit at any one time, but an alternative approach under NASA study would use a different type of satellite, known as the Acria, in complementary Nimbus coverage.

Acria would be placed in a synchronous equatorial orbit (22,600 mi. altitude) where it could scan almost con-

stantly the entire earth's surface. Time with satellites, available equally in longitude, could view almost the entire earth continuously, except for the polar regions.

Each Acria would be outfitted with both a wide-angle camera and a telephoto camera. When meteorological conditions of special interest were detected by the wide-angle camera or by a Nimbus low-altitude partner, the appropriate Acria satellite would be commanded to aim its telephoto camera at the area of interest.

Acria currently is only in the preliminary study stage. Earliest likely date for an Acria launch is around 1968, according to Dr. Milton Tupper, director of meteorological sciences at NASA headquarters. Development is likely to wait until synchronous-orbit satellite-keeping techniques have been developed and proven for other uses, such as in communications satellites.

Present NASA hopes for early implementation of an operational weather surveillance system drawn from the currently scheduled Titan program, originally intended by the Army and later transferred to the space agency. Titan, developed and built by Rocket Corp. of America's Astro Electronics Division, is one of the most complex pro-



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FIG. 1

► The entire construction of the Gerdag type pump permits almost infinite designs in continuous pumping functions in a single pump housing mounted in a sturdy pad and driven by a single shaft. Gerdag systems lack an interlocking, interlocking pressure hydraulic servo system and require no so pressure of about 5000 psi may be constructed in this manner.



FIG. 2

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heads put into orbit, but it has been one of the most reliable.

First Titan launched operated for 24 months, producing nearly 11,000 weather photos. Titan 2 operated for 10 months and Titan 3 for 41 months, each turning out more than 15,000 pictures.

Titan 4, which was launched last Feb.uary, is still operating and produced more than 13,000 pictures in the first three months of operation.

New Set of Tools

Time utilities have given the Weather Bureau scientists an entirely new set of tools, some of which require more research before they are fully developed and can be effectively applied. For example, infrared radiation patterns from clouds and the ground measured on successive Titan passes show certain characteristics in the plots of equal value radiation which may come to pinpoint the breaking growth for polar lows, according to Dr. F. W. Richard Durr, Weather Bureau chief. These patterns also may enable forecasters to locate pools of warm air in the oceans which are inhibited by certain types of fish, but use by fishermen.

Although it is premature to talk of controlling the weather, Dr. Richard Durr, for instance, the prediction that information from weather satellites might permit man to break up hurricanes before they reach full growth.

Joint Program

Under the terms of a NASA-Weather Bureau agreement, the space agency is responsible for developing the satellites, ground data and control stations, for data acquisition from the operational satellites, as well as for satellite launching. The Weather Bureau is responsible for processing the meteorological data, analyzing and disseminating it to users and for storing the data. Both agencies are jointly responsible for data analysis and accurate data for the research and development phase to assist that Weather Bureau requirements are being met.

Under the terms of the agreement, NASA bears the cost of developing and launching the development model Nimbus satellites and of developing and installing data acquisition and transmission facilities, while the Weather Bureau will bear the procurement of operational satellites.

NASA now has two developmental Nimbus satellites on order and negotiates them under way at present for two more satellites, tentatively scheduled for operational models, for launch in 1964. If the first two developmental Nimbus satellites go into orbit and perform without major difficulties, the third and fourth Nimbus will retain their operational specific designations (OS 1, OS-2).



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and become the first elements of Weather Bureau's operational system. However, the first two models are more difficult, requiring major redesign, then the third and possibly the fourth Nimbus satellite will revert to developmental status to prove out the attempted facts. In that event, the fifth and sixth satellites would take on the OS-1 and OS-2 designations.

Naturally the Weather Bureau will make use of weather photos obtained from the developmental Nimbus such as it has done with the experimental Tiros satellites.

For the upcoming year, NASA's budget request for its meteorological satellite program totals \$71,185,300. This total includes the cost of launching vehicles, but not the cost of Weather Bureau operational satellites which are funded by that agency. The breakdown of this total is as follows:

- Tiros 4, 5, 6, and 7—\$3,930,000. Tiros 5 was launched successfully last June 19 and the two subsequent satellites are scheduled for launch at roughly three-month intervals. If all are successful an additional backup payload may also be added.

- Nimbus 1, 2—\$17,254,000. These are the first two developmental models, sometimes referred to as Nimbus A and B.

- Nimbus 3, 4—\$12,068,000. These are tentatively identified as the second pair of developmental satellites, unless the first two Weather Bureau Satellites must be diverted for such purpose, in which case these satellites would possibly be transferred to the Weather Bureau.

- Meteorological sounding rockets—\$1,465,000.

- Advanced research—\$2,588,300.

- Advanced technical development—\$9,601,000.

Figures shown above for Nimbus do not represent the cost of the two space craft because NASA uses conventional funding spread over several years, and the launch costs also are included.

While NASA can provide the Weather Bureau with a Nimbus of the required performance and reliability, it

will turn its attention to evaluating new types of sensors for possible use on later models of the operational Nimbus. The basic of the Nimbus structure, in which sensors and other payload elements are located, was designed to permit substitution of different instruments.

One presently planned future experiment involves the use of a sensor under test in an intense simulated density underflow the spacecraft, to measure precipitation content of clouds. Small holes in the sensor would permit the television camera to have an unobstructed view.

Second planned future experiment will carry an infrared spectrometer which will measure infrared radiation in terms, spectral intervals in the 16 wave-number density absorption band, from which it should be possible to determine the transparency of the atmosphere at different altitudes.

The concept, originally proposed by E. D. Kopke of the Jet Propulsion Laboratory, assumes that carbon dioxide is uniformly mixed through the free atmosphere. On this basis, data from radiation measurements in 80 spectral intervals each less than 10 cm in wavenumber could be used in 18 combinations to compute temperature at each of 10 different pressure altitudes. Kopke suggested. The experimental model, using a horizontal spectrometer, is being developed by Bureau Engineering Group under Weather Bureau sponsorship.

Other planned future experiments include the evolution of radio stress detectors for tracking floodwaters and icebergs and an electronic recording television camera under development by RCA, which would eliminate the need for a suggestive tape recorder to store television pictures between passes over ground stations.

NASA expects that Nimbus satellite launch and development costs will begin to taper off in fiscal 1964, when the total Nimbus research and development effort will have cost slightly more than \$100 million.

Identify a ground station located at the North or South Pole could intercept a Nimbus satellite and send out its third weather picture on every pass, but such a location is precluded from a construction and launch viewpoint.

Most convenient companion location which NASA has selected is a site near Fairbanks, Alaska, which should permit contact with Nimbus satellites in their 30 day inclined orbit during 10 or 11 of every 14 orbits each will make daily.

To complement this coverage the U.S. currently hopes to work out an agreement with Canada for installation of a similar facility in the Canadian northwest. Discussions are under way.

Goldard Space Flight Center has just

completed the installation of its new Alaska Data Acquisition Facility, a \$5 million unit near Fairbanks, which will be used with the first Nimbus and for bringing scientific earth satellites, such as the Earthstar Geophysical Observers (EGOs) and the Polar Observing Geophysical Observers (POGOs). The Alaska facility is equipped with an 85 ft dia antenna.

Because the operational meteorological satellite system will require a full-time data acquisition facility, Goldard plans to construct a similar facility, with an 85-ft-dia antenna, at Fairbanks. The dual facility will also enable one station to serve as a backup to the other in an emergency.

Fiscal 1963 NASA budget provided \$121 million for initial work on the ground station required for an operational weather satellite system. For fiscal 1965, the agency has requested an additional \$5.5 million. It also is asking \$11 million for additional communication facilities capable of transmitting weather photos from these stations to the National Meteorological Center and to Goldard, both located just outside Washington, D. C. The communication link is to have a bandwidth with transmission capability of 96 bc.

Nimbus Complexity

Nimbus is a far more complex space craft than its Tiros predecessor. The first model, scheduled for launch in the second quarter of 1963, is expected to weigh about 700 lb., more than twice the weight of Tiros. Launch vehicle will be a Thor Agena B, first from the Pacific Missile Range.

NASA is studying the Atlas Agena B or a modified Thor Agena B as launch vehicles for later models of the Nimbus to generate greater payload weights, according to Harry Price, Nimbus project manager at Goldard Space Flight Center. The first model will not carry the dual camera packs and other standard equipment which Price believes are needed to achieve the desired operating lifetime of six months or longer.

One example of the increased complexity of Nimbus is its attitude via observation. When Tiros was operational so that its cameras aimed at the earth only for about 20% of the time, the Nimbus will be earth-oriented by means of horizon sensors to that its cameras always are directed toward the earth.

Two solar cells are mounted along the surface of the three-shielded spacecraft which extends only a fraction of the total cells to dawn twilight, providing an output of about 33 watts. The Nimbus solar cells are mounted on two large paddles which automatically are tilted toward their peak sun to aim the cells at the sun. The paddles also are directed toward the sun in azimuth by



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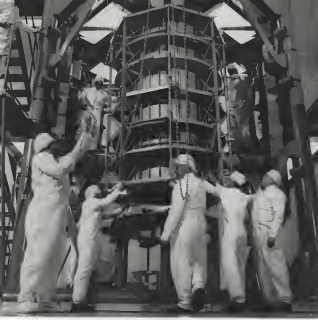
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Drawing of new Space & Missile Center which will further expand Grumman's aerospace activities, providing accommodations for a larger scientific, engineering and support staff.



series of sensors on the spacecraft which assist it in size. Output of the Nimbus solar cells is about 440 watts, or 20 times that of the Titan.

Where the late model Titan satellites carried two wide-angle television cameras, the first Nimbus will carry a pack of three cameras and later models are expected to carry two such packs, or a total of six cameras. The second pack is intended as a backup, but probably will be used on alternate orbits to ensure the equipment and keep a check on its operability.

When each camera pack, the three cameras will be trained to provide slightly overlapping coverage. Combined area of surveillance from the pack will be approximately 1,500 sq. mi., at right angles to the satellite direction of motion, and 350 naut. mi. deep, at an altitude of 600 mi.

Photos will be made at approximately 100-sec. intervals during daylight passes, providing mosaic coverage of terrestrial pictures in the direction of motion. During the course of each orbit, a Nimbus camera pack is expected to produce approximately 1,500 individual pictures.

Videores used in Nimbus will have an 800-line scan per frame, compared with 500 for Titan. This will give a resolution of about one-half mile, compared with approximately two miles for Titan.

Infrared Sensors

Enhanced sophistication of Nimbus also shows up in its improved infrared sensors, to provide long-range detail on nighttime cloud cover and earth heat balance. Presently planned infrared radiation sensors include:

- High-resolution infrared radiometer, sensitive in the 3 and 4.2 micron regions, will sense in the eye of the Nimbus for night passes to map the temperature of clouds as of the ground and ocean, in cloud-free areas. Results are expected to be within approximately 3 m., compared with 15 m. resolution obtained from Titan scans.
- Medium-resolution infrared radiometer, will measure radiation in the infrared and gas window bands. These include 0.2 to 4.6 microns, earth-fluxed solar radiation 0.55 to 0.75 microns, solar energy reflected from daytime cloud cover, 6.5 to 7.0 microns, water vapor absorption, 10 to 11 microns, atmospheric moisture, and 7 to 8 microns, thermal radiation from the earth.

Another interesting difference between Titan and Nimbus programs is that Goddard is acting as prime contractor and system engineer for Nimbus, a role which RCA performed for the Titan. The basic Nimbus spacecraft configuration and structural design was done by Goddard, and it has

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selected the supplier of Nimbus subsystems and is following the supplier's plans.

General Electric's Missile and Space Vehicle Department is the major Nimbus contractor, with responsibilities for detailed design of the spacecraft and its subsystems, and for integration of all subsystems into the spacecraft. GE also is developing the attitude stabilization control system.

Major Contractors

Other major contractors on the Nimbus satellite program include the following:

- Radio Corp. of America: Videom

camera pack and solar cell paddles. RCA also is providing clock recovery, a tape recorder for the high-resolution infrared sensor, and is developing the advanced electrostatic scanning camera.

- ITT Industrial Laboratories: High-resolution infrared radiometer

• Santa Barbara Research Center: The Hughes Aircraft subsidiary is developing the medium-resolution infrared radiometer. Hughes will also be the job of building the PCM-AW telemetry transmitters.

- Redstone, Inc.: PCM telemetry

• Tecon Instruments, Inc.: Transmitter for medium-resolution sensor

- General Electronics: Stand time counter

• Remson Engineering: PCM telemetry and medium-resolution sensor data recorder

- Aero Gas Attor: Medium-resolution sensor electronics package

• California Computers: Clock control package

- Standard Research Institute: Data utilization studies

Nimbus Slippage

First Nimbus launch date has slipped from the last quarter of this year to the second quarter of 1965, largely the result of trouble encountered by GE in the design of its horizon sensor for the attitude control system (AW June 4, p. 35).

The major problem has been the difficulty of determining earth horizons to acquire precision when there are clouds present whose radiation distorts the apparent position of the earth horizon.

General Electric is redesigning its horizon sensor to make it sensitive to longer wavelengths in the 12 to 35 micron region, reducing horizon sensor scanning, speed and developing laser-based principles in the hope of solving the problem, Press said.

There have been problems and delays with other subcontractors for the Nimbus. But Press said that is characteristic of spacecraft and their peripherals. He considers that the qualifications tests which Goddard requires for its spacecraft and payload subsystems are extremely demanding, higher even than those that are usually imposed for military equipment.

Project Office

Nimbus project office divides its programs into four major areas: spacecraft, launch vehicle, data acquisition and data utilization. The data utilization office is headed by a Worcester Branch representative, while the head of the data acquisition office is a member of the Data Systems Division of the GE. Standard tracking and data system director, assigned to the Nimbus project. The branch vehicle office provides liaison with the Marshall Space Flight Center, which is responsible for providing baselines.

Majority of the Nimbus project office manpower is applied to the spacecraft itself, with individuals assigned to monitor development of the many payload subsystems.

Built of the subsystem contracts, and the one with GE for the spacecraft are on a cost-plus-fixed-fee basis. Program Evaluation Review Technique (PERT) is being used on the major Nimbus contracts, including those with General Electric, Radio Corp. of America and Redstone, Inc.

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OSCAR'S COMPUTING CENTER, shown during M43 Mercury flight, performs launch, orbit and recovery computations which are actually transmitted to Cape Canaveral Mission Control Center for display. Control launch, orbit and recovery parameters are shown in fluorescent display at left while status of all network stations is shown, at right.

NASA Expands Tracking, Data Acquisition

Washington—Advanced manned spacecraft missions and the vastly increased amount of data that will come from scientific satellites such as the on-going geophysical and atmospheric observations are requiring National Aeronautics and Space Administration to continue expanding its tracking and data acquisition facilities.

In Fiscal 1963, NASA has requested \$224 million for operation and expansion of the established and wholly but enabled men to extend fast but secure and more recently himself into the hostile space environment. Of this total \$74.5 million is intended for equipment and manpower, \$67.8 million for software development and \$81.6 million for construction work.

The space agency operates three tracking and data acquisition networks around the globe, from Alaska to South Africa and Australia, each designed to perform a different mission. But like its sibling, only a fraction of the total is apparent. Generally unseen are the extensive data processing, reduction, computation and communication facilities at the Goddard Space Flight Center and the Jet Propulsion Laboratory, which form as essential part of the overall system.

The three networks are: • **Manned space flight network**, some times called the Mercury network, consisting of 16 stations, two of them ship-

based, plus two down range stations of the Atlantic Missile Range. Land stations include the U.S. Air at Grand Canary Island, Nigeria, Zanzibar, Ceylon Island, Mexico and two in Australia.

• **Earth satellite network**, presently

consisting of 13 Minitrack stations with three new facilities under construction or planned. Stations outside the U.S. include Ecuador, Peru, Chile, Australia, South Africa, Newfoundland and England. There also is a 17-station optical tracking network, with stations outside the U.S. located in Argentina, Aus-

Tracking and Data Acquisition Facilities

	S-Band Radar Tracking (Verifon)	C-Band Radar Tracking PPS-16	Telemetry & Control	Command Control
Woomera, Australia	—	—	X	—
Canton Island	—	—	X	—
Kauai Island, Hawaii	X	X	X	X
Peart Annapolis, Gold	X	X	X	X
Gwynedd, Mexico	X	—	X	—
White Sands, N. Mex.	—	X	—	—
Corpus Christi, Tex.	—	X	—	—
Eglin, Florida	—	X	—	—
Cape Canaveral, Fla.	—	X	X	X
Grand Bahama Island	—	—	—	—
Grand Turk Island	—	—	—	—
Brussels	X	X	X	X
Grand Canary Island	X	—	X	—
Kano, Nigeria	—	—	X	—
Zanzibar	—	—	X	—
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Alaska, Australia	X	—	X	X
Atlantic Ocean Ship	—	—	X	—

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• **Deep Space Instrumentation Facility** for lunar and interplanetary spacecraft stations, consisting of stations at Goldstone, Calif., Sardinia, Africa and Australia (see p. 175). The stations are sited approximately 120 deg apart in longitude to enable at least one in view as a space probe at all times despite the rotation of the earth.

With a list of station uses that sounds almost like a roll-call of the United Nations, NASA officials responsible for the selection of station locations and their subsequent operation must keep eye on the international situation and internal political situations in countries where stations are located. This requires close liaison with the State Department. NASA seeks to prevent a decision to expand or change the role of a particular station, based entirely on technical factors, from becoming an original political snarl, according to Edmund C. Buckley, director of the Office of Policy and Data Acquisition at NASA headquarters.

NASA's plan is to employ automatic to operate and maintain stations outside the U.S. to the maximum extent possible, consistent with the availability of required skills. Stations in Australia, Canada, England and South Africa are managed by contract.

In most instances, the lead for the station is provided by the host government at no cost to NASA. The lead for the NASA station at Garmisch, Mexico, was donated by a small lunar with a lunar interest in space exploration. For early half of the design station, the host government provides some financial support for station operation, Buckley said.

Responsibility for the three networks is divided as follows:

• **Manned space flight—**Goddard Space Flight Center's directorate for tracking and data systems, headed by John T. Mangel, is responsible for design and operation in a support service to NASA's Manned Space Flight Center at Houston, Tex.

• **Earth satellite—**Monsie's group has similar responsibilities for the network in support of Goddard's own scientific, communications and meteorological satellite programs. Personnel at the tracking and data systems directorate number approximately 530, representing about 14% of the total at Goddard. Approximately 40% of the group is professional.

• **Deep space—**Responsibility for design and operation of the deep space probe network is assigned to Jet Propulsion Laboratory in support of its own unmanned lunar and planetary spacecraft program (see p. 175).

Although the three mainly are re-



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Extensive teams of engineers build cryogenic facilities of any size or capacity. Feedback of operating data from Air Products plants throughout the world leads to further advances in design, engineering, and field advice.



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Differential capabilities from a single Defence and Space Division source mean speed, economy, and performance on every requirement from conceptual stages to a complete cryogenic facility.

actively related to the Mercury Control Center at Cape Canaveral. Approximately 16 of these are designed to monitor or alarm instrumentally. The remainder are needed for later analysis.

Six stations are outfitted with command and control equipment, to enable them to activate telemetry or other capsule functions if necessary. Five are directed toward the telemetry, located at retro-fire areas—Cape Canaveral, Bermuda, Hawaii, Ft. Azules and Cavanaugh—and the sixth is located at Machu.

Hotline Network

These stations are linked into a hotline network by 141,000 circuit miles of telephone, teleprinter and high speed data circuits, using land lines, submarine cables, microwave links and point-to-point radio.

Capsule position information is continuously converted at each site into a form suitable for transmission by teleprinter circuits and routed directly to Goddard. Output from the Goddard computer is transmitted instantly to the Mercury Control Center at Cape Canaveral via high-speed data circuits, operating at a 1,000-bits-per-second rate.

Eleven of the 16 stations in the Mercury network, plus the two Atlantic Missile Range downrange stations, are now interconnected by voice circuits. The remaining five stations, presently linked only by teletype, will soon be connected to the voice network.

The communications network, built by an industrial team headed by Western Electric and including Bell Telephone Laboratories, Bessie Corp., Bessie & Rose and International Business Machines Corp., was designed to assure the reliable communications to vital to manned orbital missions.

For example, two separate circuits are provided between the computer facility at Goddard and the control center at the Cape, either of which can provide required service. If both should fail, a backup pair of circuits using a different geographic routing are provided. Diagnostic communication channels are provided to all key stations, with alternate routes available on a standby basis.

Computing Center

Four large digital computers, two IBM 7090s at Goddard, one IBM 709 at Bermuda and an Atlantic Missile Range 7090 at the Cape form a network during an orbital mission.

The Goddard computing center furnishes, throughout the mission, to provide the Mercury Control Center at the Cape with a running display of important launch, orbital and telemetry information. It is located at Goddard

because that is the center of the NASA worldwide communications network, into which tracking data flow, but it is linked to the Cape by the previously mentioned high-speed data circuits.

USAF 7090

The Air Force 7090 located at the Cape is used by the range safety officer during initial portion of the launch to predict the booster's impact point as one the booster should deviate from flight plan. It is therefore referred to as the RF-7090. At lift-off, data on booster position is obtained initially from the AN/FPS-16 radar at the Cape

which feeds into the RF-7090. The RF-7090 output also is transmitted automatically to Goddard for use as a range launch computer for display at the Mercury room.

When the booster reaches an altitude sufficient that it can be tracked by AMR's Area Mark 2 system, the RF-7090 changes over to receive its data on booster position and velocity from the Area Mark system, which usually is more accurate than data from the FPS-16.

Approximately 30 to 60 sec. after lift-off, the General Electric/Bermuda guidance system takes control of the booster, providing position and velocity

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ity data similar to that available from the B-70's. This also is transmitted constantly to Goldlad.

When both B-70's and GE/Bowditch data are available simultaneously, a data quality monitor at the Mercury center determines which is better and by accurate celestial objects the data source which Goldlad computers will use.

As the booster heads down range, it covers within view of the Bermuda radar. When the Mercury network was first installed, the only link with Bermuda was by radio, which did not permit transmission of radar data at high speeds and ran the risk of propagation interference. Because the Bermuda data is obtained during the critical ascent or short descent period, NASA decided to install an IBM 709 at Bermuda to make independent calculations on the spot.

Recently a microwave cable has gone into service between the U.S. and Bermuda, permitting transmission of radar data directly to Goldlad. While the 709 remains in use, NASA is now considering shifting that function out of the Bermuda station.

Nowadays the data from the Bermuda radar will be more accurate than that from the Cape because of their closer proximity to the booster at this period in flight. But the choice of data source used by the Goldlad computers is made by Mercury Control Center.

Once the control center determines that the capsule has been injected successfully, it switches the Goldlad computers to their orbital computation mode.

Both Goldlad computers run through identical orbital computations, using the latest data, and compare answers in a check procedure. But only one answer is in line, feeding its output to the Cape for display and to the Goldlad control display.

Power Sources

One computer operates from conventional electric power, while the other operates from a diesel-powered generator located at Goldlad. This assures that loss of normal power will not disrupt the operations.

During the orbit mission, the Goldlad computers continuously calculate and display where and at the Cape the estimated impact point for the capsule if it should suddenly become unable to initiate reentry. (There is a 30-sec. built-in time delay between the instant reentry or ground station status reverts action and the time the retro-rockets will fire.)

The computers also continuously estimate the time at which the retro-rockets will need to be fired to bring the capsule into the intended recovery area after completion of the present

orbit, and after the final planned orbit. They also continuously calculate reentry rocket firing times to bring the capsule in at one of five contingency recovery areas if an emergency develops. Only the firing time to the next possible contingency recovery area is displayed, however.

When the Mercury center receives a signal that retro-rockets have fired, the Cape instantly advises Goldlad of the time and the number of retro-rockets fired. Goldlad operators insert this information manually into the 709's and the computers then compute the estimated impact point.

A number of factors can cause the actual impact point to deviate from the first estimate, however, as the recent MA-7 orbital mission dramatically illustrated.

This is why the first order report on capsule position after retro-rocket firing is so eagerly awaited, since it gives the first data on the actual reentry flight path and permits a more accurate impact point calculation.

During the MA-7 flight, the first data data received after retro-rocket firing came from Ft. Aguilar. Based on this, the Goldlad computers came up with a new impact point which differed from the early estimate by about 240 mi.

Initial reports at both the Cape and at Goldlad was that "the computer must have slipped a cog," according to one Goldlad spokesman, because the mission had previously proceeded as planned, except for capsule fuel consumption. During the reentry flight the computer-calculated time for retro-rocket firing had not changed by more than two seconds.

Goldlad is run the calculations based on Ft. Aguilar's radar data and came up with the same answer—a 240-mi. overshoot. This later was confirmed by radar data received at the capsule came within range of the Cape's Chieftain, Right and Left Cassini stations.

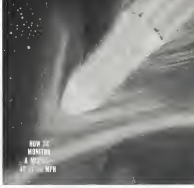
Altitude Carpenter was picked up within 10 mi. of the impact point predicted from the Ft. Aguilar radar returns as easily as can be determined from the position report made by the aircraft which first sighted the capsule, according to a Goldlad spokesman.

Reliability No Accident

The excellent reliability of the Mercury network to date is the result of a long and agonized program which includes extensive outcasing and pre-flight testing before each mission.

The network is operated, checked-out, maintained and continuously run by the Manned Space Flight Support Division, one of five divisions reporting to John Mengel, Director of NASA's M. S. F.

The two 709's computers and other



Specified as 11.4, a 15-sec. delay from Converter is only one of them. Moments after the start, also checked into advantage, an alarm sounding horn is started to react the other end of the plug as the rocket vehicle plugs into the atmosphere of 50,000 psi.

About the re-entry monitoring aircraft a battery of photographic, photostatic, and telemetric devices watches the descent and of the flight. A P.A. instrumentation has been installed by an Aero-Engine Research Laboratory machine tool. It is used to provide a magnetic tape a graphic record of important electromagnetic and time-sequential information which is recorded in the development of advanced re-entry vehicles and in the country's air and space program.

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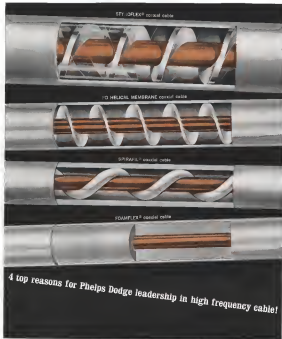


Above—Photo of Test made in early. Below—Detailed instructions about the maximum amount. Below—Testing of Aero-Engine Research Laboratory.



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computers at Goddard used for related tasks recently on under the sponsorship of the Data Science Division, also under Menzies. Dr. Joseph W. Slay is acting director of the division.

Shortly before an orbital mission, the operational responsibility for the Goddard computer center shifts to the Manned Space Flight Support Division. It oversees all of Goddard's responsibility for the network's operation.

At that time, the Goddard center comes under James J. Donaghy, known as the Goddard operations director, who works for the Manned Space Flight Support Division.

Approximately 40 days before a scheduled orbital mission, the launch monitoring subsystem, involving facilities at Bermuda, AMR, and Goddard, begins an extensive test simulation, using pre-recorded tapes, according to E. F. Ockersford, Jr., computer supervisor of the division.

Roughly a week before the scheduled launch date, flight controllers from the Manned Spacecraft Center arrive at each station in the network, where they then phase under the Mission Control Center's sequence.

Flight controllers bring pre-recorded tapes which will simulate a complete orbital mission for each station. In an effort to achieve realistic simulation, the tape program includes faults and troubles, such as a telemetry signal from the capsule which indicates it is running out of fuel, or an equipment failure at one or more stations.

All positions are manned so they would be for a regular flight and the entire network, run through the mission, complete with exchange of voice and telemetry messages. Station maintenance personnel also can be notified and brief sessions tests on all equipment.

Pre-Launch Preparation

Approximately one hour before a scheduled lift off, usually at around 10 p.m. the night before a launch, Goddard begins its countdown. First a group of IBM operators comes in to cover out a pre-launch maintenance program on the two 390s. They are followed shortly after midnight by a second group of IBM specialists who check the data flow throughout the network.

Radars at each station are brought up to target heights of lookout position and range, to check, preference and accuracy. Each radar ship is joined at a prescribed azimuth and elevation angle, to provide an input to the Goddard computers to simulate tracking the capsule in orbit. This means that data from all radars are being processed at the site and transmitted to Goddard. High-speed data links to Bermuda and to the Cape also are tested.

Approximately four hours before lift-



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off. Goldard conducts a computer and data flow integrated subsystem test. The Goldard computer uses a specially prepared program, transmit a "call" to each station, which should evoke a prompt response with the appropriate reply. If the station gives the wrong reply, no reply, or takes too long in replying, something is wrong.

These computing center tests, under flight director Walter Adams, normally will be completed by approximately July 25, by which scheduled lift-off, at which time Apollo Period, the flight director, takes over. Both men report to Deegan.

Trajectory Confidence Run

The next test is the trajectory confidence run, in which the Tennessee center, the SPS-16 and Apollo station at the Cape and the GE-Barrington guidance system translate a launch sequence, with their data being used by Goldard to compute the trajectory. On days when no mission is scheduled, a similar test can be run using pre-recorded tapes. Mercury flight controllers participate in the simulated lift-off, which takes about 30 min and checks out the entire coupling.

Approximately an hour before lift-off, the trajectory confidence run is repeated, except that tapes of solar data make during the first run are used.

At about 10 min before lift-off, Goldard begins to exercise one TDRS, using a cycling program in which the computer activates displays at the Cape which can be checked by the control center there. Approximately five min later, the second TDRS begins its cycling tests. These continue until launch time.

When the actual launch has taken place and the capsule is in orbit, Goldard automatically sends a telemetry message to each station advising the expected capsule altitude, elevation and range during its next pass over the station. In that tracking and telemetry information can be properly oriented in advance. Each message gives four different "look angles" (azimuth, elevation, range and time for these coordinates) in case the station fails to acquire the capsule when it first comes within range. The first message is sent 45 min before the capsule is due to pass over and is updated 25 and again 5 min before the pass.

When the mission is finally completed, the Goldard center does not shut down and take the afternoon off. It immediately launches a post-mission analysis of network performance and processes critical data for transmission to the Mission control center.

The network is continuously undergoing improvement. For example, the Atlantic shipboard station recently has been authorized to give it a command



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Memorex scientific approach to magnetic tape making benefits users

Too frequently, the best available magnetic tapes have not been good enough for many tape users. The reason: lack of consistent quality and reliability—the result of tape-making practiced as an uncertain art.

Memorex approaches tape-making as a science. Manufacturing processes and techniques uncommon in the industry have eliminated the uncertainties in tape-making and their consequent demeriting effects. The result: Memorex magnetic tapes not merely incomparably better than products available to date, but materially better in important parameters.

In early 1961, Memorex Corporation undertook to turn the art of tape-making into a science. It put together a team of highly qualified people offering a diversity of talent and breadth of experience unique in the industry. Significantly, the group possesses unusual depth in chemistry, process engineering and automation, as well as in magnetic recording technology and data processing.



Within the white walls of the plant, which bespeak Memorex emphasis on cleanliness, are the most advanced tape manufacturing facilities in the United States. A conspicuous feature of the plant is its control and elimination of dust and other possible contaminants of production. Extreme emphasis upon freedom from airborne dust particles provides for Memorex tape users a like freedom from unwanted drop-outs which could otherwise result from contaminated dust. Memorex uses dust filtration equipment similar to that employed in atomic energy facilities to prevent the escape of radioactive particles. The photo

below shows a portion of the complex system of air filtration, humidification, de-humidification, heating, and cooling which provide the special environment for Memorex tape manufacturing.



Memorex Research

A wide awareness of tape users' problems is one key to product development at Memorex; deeper understanding of the many parameters of tape is another.

Knowledge of tape users' problems—tape wear, oxide shed, head contamination, head wear, and obtaining better short wavelength performance and pulse response—derives from earlier experience of many Memorex researchers. Working with equipment manufacturers and sophisticated tape users, they obtained insights useful in developing meaningful solutions to many tape problems.

The aim of much Memorex research is to develop vital fundamental knowledge, lack of which continues to limit product improvement in the magnetic tape industry. The research staff has extensively investigated the problem of tape wear and the exact way in which wear influences tape reliability. Basic causes of different types of drop-outs have also been determined. Factors affecting the response at very short wavelengths and high packing densities are under study. Other study areas include the significance of the condition of tape edges and the electrostatic behavior of tape.

To establish a true technological basis for magnetic tape development and improvement, it is also essential to obtain critical measurements of the electrical, chemical, and physical properties of tape. Memorex, therefore, has set up one of the most thorough and accurate testing facilities in the world for tape analysis. It encompasses a number of new tests and techniques, which go well beyond the specifications of the most critical commercial and military users, and it utilizes advanced Memorex-developed test instruments, which achieve a degree of sensitivity and precision otherwise unobtainable.



An airtight degree of accuracy in measurements on magnetic materials is made possible with the use of a vibratory sample magnetometer, designed by Memorex research engineers. Below, on a part of a durability test which Memorex makes on every production run, a performance check on a digital tape handler provides the permanent photographic record of a computer tape's pulse output.



Memorex Manufacturing

The strength of Memorex manufacturing people derives from their extensive experience in process engineering and chemical and pharmaceutical production. This background has enabled them to obtain for Memorex the consistency and reliability of quality production which is its objective.

Throughout the manufacture of Memorex tape are employed the principles and techniques of automation, production-line monitoring, and process control. As a consequence, you will find extreme consistency in the quality of Memorex tape, both within-a-roll and roll-to-roll. Also borrowed from the pharmaceutical industry are the standards of cleanliness and the techniques of sterile-room manufacturing which help insure consistency and freedom from drop-outs.

The Memorex manufacturing process incorporates many innovations, in the areas of formulation, dispersing, treatment of backing material, coating, drying and curing, slitting, and even in packaging. Traditional processing methods were held sacred, not because of any desire to be different, but because innovation was considered essential to overcome quality limitations inherent in commonly used methods.



Access to clean room areas is through change rooms where street dress, jewelry, and cosmetics are removed. Left-free clothing, caps, and boots are dozed from another locker across the

barrier-bench. Below, an ultrasonic cleaning system, designed by Memorex engineers, removes foreign matter from film base material prior to coating.



Memorex Quality Assurance

Memorex standards of quality, which exceed the specifications of commercial and military users, are established by its Quality Assurance Laboratory, an independently constituted function which cannot be subjected to delivery schedules and other pressures of a manufacturing operation. The Lab also has the responsibility for continuous audit and endorsement of its standards in the drop-out checking and other quality control activities of manufacturing. At least one tape slit from each production run is comprehensively tested.

It is not necessary for Memorex customers to engage in extensive and costly testing of Memorex products, because of this high order of quality control and this quality assurance philosophy. We conceive it to be our responsibility to know and to certify the quality of Memorex products without reservation. Our warranties reflect our integrity in practicing what we preach.



Slitting of rolls of the control web into narrow tape widths is one of

the control operations carried out in a completely controlled environment. Below, ultraviolet spectrophotometer and gas chromatograph analyses are used to monitor the resin binder systems and its coatings.



Type 22 Computer Tape and Type 33 Instrumentation Tape

Memorex manufactures only precision magnetic tapes for computers, data acquisition and analysis systems, telemetry and instrumentation recording systems, and existing audio frequency applications. Memorex precision tapes are now available in widths, lengths, and reel sizes for all commercial tape drives.

Type 22 Computer Tape uses new standards of wear and durability. Users will find Type 22 gives performance comparable to premium tapes at substantial savings.

Type 33 Instrumentation Tape offers performance and cost advantages to analog recording users.

Write for comprehensive specification sheets. Upon request, we shall also send you literature describing Memorex research and manufacturing capabilities.



MEMOREX CORPORATION
PRECISION MAGNETIC TAPE
SANTA CLARA, CALIFORNIA

and control capability that will be needed for use in eight orbit missions. The ship probably will be stationed near Guam for each mission.

The two shipboard stations plus those at Nauru, Zanzibar and Cienfuegos, which formerly had only tele-type communications with the rest of the network, are being outfitted for voice communications.

Telemetry data from the capsule during the orbital mission phase, now received and displayed in the Denham station and relayed by voice to the Cape, soon will be relayed automatically and displayed at the Cape.

For the smaller (100-lb.) Marsok, flights whose main information is needed on the ground to monitor the status of the astronaut and the capsule, onboard telemetry equipment will be installed at all stations.

The original Mercury network was laid out to assure that voice/telemetry contact with the capsule could be maintained for approximately 4 min out of every 15 min in orbit. During the 10-day mission, there will be some areas in which contact with the capsule is available only once during an orbit. But by that time NASA expects its knowledge of capsule and astronaut

performance to be sufficient to tolerate that.

By stationing the modified ship near Guam and moving the Indian Ocean ship-based station west to near Madagascar, NASA expects to steadily increase its ability to handle the space mission.

For Gemini capsules orbiting for land recovery, additional precision radar over the recovery area may be needed, depending upon the site selected.

But the relatively low-altitude coverage of network radars will not be suitable for Apollo lunar missions. For circumlunar and lunar landing missions, elements of the present deep space probe network probably will be used.

Earth Satellite Network

The earth satellite network is an outgrowth of the original 11-station Minuteman network and the associated optical tracking network designed and built for Vanguard satellites as a part of the International Geophysical Year program in 1957-58. At that time orbit altitudes were expected to be low, period seasons and output data were modest and economy was an overriding consideration.

NASA now is expanding the network's capabilities, already improved from its original configuration, to handle extremely high data rates from sophisticated scientific satellites. Goddard has developed an improved accuracy tracking system, called range-and-angle-velocity system, which is substituted for radial field tests now used.

Operation and maintenance of the earth satellite tracking network is the responsibility of the Operations and Support Division, headed by F. J. Friel, Jr.

Minuteman is an interferometer type of system which determines satellite position in a north-south direction by comparing the phase or signals received from a satellite transmitter at each of two fixed antenna arrays situated as a north-south direction. A similar phase comparison made by two east-west oriented antennas establishes satellite position in that plane. By using two or more pairs of antennas, each at different baseline distances from the center of the site, increased accuracy without analogies can be obtained.

The 11 original Minuteman stations operated at 100 mc, a frequency assigned for the IGY Vanguard program. Antenna configurations were lined out with highest accuracy for satellites in low-inclination orbits, the only ones then planned.

Since then, two stations have been added and several stations in Latin America have been moved to provide sites in England, Alaska, Newfoundland and Mauritius for capsules in coverage of high-inclination orbits, according to

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ground terminals. Distance is determined by measuring the phase shift that occurs during travel to and from the surface while stage rate is determined from the resulting Doppler shift. The transmitted carrier wave contains a number of different frequency signals that subcarriers to provide high accuracy phase delay measurement without ambiguity.

The new system is intended to supplement, not replace, the Minuteman stations. It will be used only when the accuracy accuracy is needed and the surface can afford the added weight of the transponder.

Large Antennas

To handle the increased bandwidth data requirements of the OAO GAO GPO and POGO sensitive stations, Goddard is building two new tracking and data acquisition stations with 55 ft. antennas and has requested funds for two more in Fiscal 1967.

The first, the Alaska Data Acquisition Facility, near Fairbanks, is nearly completed and will be operated by the University of Alaska under NASA contract.

A second facility now under construction at Research, N. C., is slated for completion early in 1968.

Recent of the heavy ship, required to control and monitor the data from the existing observatories NASA has asked for funds for another 55-ft. dish at Research and a fourth antenna to be located in the Far East. Sites under consideration include Japan, Okinawa and The Philippines.

To illustrate the heavy work load which requires the new facilities, the Executive Geophysical Observatory is expected to be in its high-speed operation, producing nearly 100,000 data for 20 ft. out of even 40-42 ft. orbital period. The latter orbit GAO, GPO and POGO will be producing data and reporting command instructions from the ground for 15 min. out of every 90-min. orbit.

The Fairbanks antenna, standing 120 ft. high, is the largest yet built in which the dish moves in north-south and east-west coordinates rather than in azimuth and elevation. This enables the antenna to track a satellite going directly overhead without having to swivel 180 deg. in azimuth.

The antenna has multiple feeds that enable it to receive at 136 mc, 400 mc and 1,200-2,200 mc. Although it can be used both for tracking and telemetry at all three frequencies, the Alaska Minuteman station probably will be used for tracking at 136 mc. The GAO and POGO stations will be used for tracking at 400 mc while the POGO station will transmit at 1,200 mc.

The antenna tracks the satellite automatically, using an azimuthal



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propelled, inter-rocket, rocket built by Collins Radio. The Alaska inter-rocket was built by Hughes, while the one at Rossum is under contract to Rust Aircraft.

New Developments

The Trucking Systems Division, under Schneider, is responsible for developing new techniques and equipment to improve the solid-to-tracking net.

Approximately 25% of the division's development program is carried on in-house, while the remainder is contracted.

The new stage and stage case tracking system was developed here, and a working breadboard model was constructed in house to evaluate feasibility before the contract was awarded to Motorola. A similar procedure was followed for a new digital PCM/AM command system, expected to be more secure than the present analog time command system. The new system also provides 75% more words, many more than are available with the existing system.

Continuing studies, the division is increasingly concerned when it comes to applying new techniques where feasibility is questionable, promising to enhance reliability, low power consumption and long life.

Sea, Goddard will call for industry proposals for a new 15-in. solid-rocket motor with all solid-state components, which can also be used for 400 sec and 1,700-2,300 sec by substituting different front ends. The objective in thinking over from the present vacuum tube receiver is based on the projected advantages which solid-state equipment provides, Schneider says. The lower power consumption is an important factor at remote sites, which must provide their own electric power, and the lower heat dissipation shifts the burden on air conditioning power load.

The solid-state equipment also should be smaller, and this is important in the event of equipment installed at strategic points. Package miniaturization, however, is the expected reliability which adds state equipment promises.

An interim stage case Goddard is expected to be operational this fall, enabling the division to increase its in-house capability to procure. Some modest vehicle study consists in solid-state suppression and low-loss designs are planned, Schneider said.

The division also has a modest solid-state program in low-loss amplifiers of the dash, parametric type. More amplifiers are not being used at present because of the problems of cryogenic cooling, and probably will await the development of a suitable diode device cryogenic version suitable for use in remote areas.

A major effort is under way to im-

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GUIDED MISSILES RANGE DIVISION
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point the timing reference used throughout the Guided missile network for most precise correlation of measurements made by several stations. The present system uses high-frequency broadcasts by the National Bureau of Standards' station WWV, to provide both a reference frequency for daily calibration of the crystal oscillator at each station, which serves as its clock and an accurate time standard.

Because of propagation characteristics in the HF band, the present WWV signal provides marker tracing which is accurate to within approximately one or two microseconds, Schneider says. While this is adequate for the present Mariback network, the new Guided range-and-range-rate system will require an order of magnitude improvement.

A two-step implementation program is under way now. The first phase calls for using a transmission at very low frequency (VLF) in combination with a receiver having a long time constant (integration time) to fix the station oscillator at the correct frequency, perhaps once a day. But the WWV transmissions still will be used to obtain the true marker. This should provide a true reference accurate to within about one-half microsecond, Schneider believes.

Meanwhile, Guided is sponsoring work at NBS to develop techniques by which a brief time marker can be transmitted at VLF. If this can be developed, VLF would then be used both for oscillator calibration and time marking, with an error of perhaps 0.1 milliseconds.

Although radio and radar tracking systems have the advantage of being able to operate in all types of weather, optical trackers are more accurate and have a built-in calibration because of the star background.

One of the biggest shortcomings of present optical trackers is the many kinds of labor required to analyze tracking films and calculate relative position.

The Tracking Systems Division is negotiating a contract for development of an automatic optical tracker which is expected to be able to lock onto a new target more quickly, and track it in daylight and twilight hours.

If this can be achieved with required accuracy, the accuracy and elevation aiming point can be read out directly on the data console as well as an automatic tracking radar, greatly expediting the data analysis and giving optical tracking a big boost.

The division has an investigation, as an in-house program, other areas which might be used for automatic tracking during complete darkness. Some future contracts in the work area appear likely.



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Goddard Data Processing Role to Increase

Cornell, Md.-Goddard Space Flight Center is preparing for the avalanche of data that will be telemetered back from the coming series of advanced scientific satellites, such as the orbiting solar, astronomical and geophysical observatories.

Explorer 12 (S7) provided a sharp warning of things to come when it produced some 6,000 mbs of telemetry tape in its three months of operation. But Explorer 12 transmitted data at the rate of 150 bits per second, high compared to many previous satellites, whereas the Explorer Geophysical Observatory (EGCO) will be designed to transmit at rates up to 60,000 bits per second, or 100 times as fast, with a corresponding increase in the amount of data collected.

Although interest sometimes centers on the more glamorous aspects of National Aeronautics and Space Administration's scientific satellites, the end objective of the whole program is to obtain new information and reduce it promptly to a form suitable for use by the scientists whose experiments are in orbit.

The matter of controlling and selecting experiments on sophisticated satellites such as the Orbiting Astronomical Observatory is a related problem. These experiments will be designed to permit the ground station to select the most important ones, but this would be planned carefully to permit maximum useful data acquisition with minimum expenditure of spacecraft fuel and power.

There are some of the challenging problems assigned to the Space Data Acquisition Division, headed by Dr. R. J. Casare, Jr. It is one of five divisions in Goddard's tracking and data systems department, under John T. Murphy.

The division was created almost a year ago to coordinate in one group all of the command, control and data acquisition functions which previously had been divided among several divisions.

Spacecraft Responsibility

The division's responsibility with regard to the spacecraft is limited in the coming, which converts experiment data measurements into the required digital format for transmission to earth, and the decoder, which receives ground commands and converts them into suitable form for operating satellite controls and experiments. Responsibility for the spacecraft telemetry transmitter and receiver is assigned to the Spacecraft Technology Division under the direction of Dr. James H. Van Allen.

The division of responsibility means that the digital coding format used to transmit data to and from spacecraft is compatible with ground data processing facilities. Within the division, the spacecraft functions is assigned to the space electronics branch. While car-

rier scientific satellites are using pulse frequency modulation (PFM), the trend is to pulse code modulation (PCM) for higher data rates in the more complex, payload, according to Dr. Casare. The branch carries out paper design and builds breadboards to indicate feasibility, but flight hardware usually is developed by satellite contractors.

Responsibility for design and prototype construction of ground-based data processing and display systems, operating in real time to give NASA ground control stations a running picture report on the operation of a satellite and its payload, is assigned to the space data control branch. For example, the OAO will telemeter back approximately 120 status report items on the state of its own instruments, power and internal conditions plus data on sensor measurements.

These must be processed in real time, automatically compared with expected values and new data points displayed so that ground controllers can take necessary corrective action and transmit new commands to the spacecraft.

The advanced system implementation branch supports the space branch

when a new equipment is ready for production by a contractor. This support includes measuring the contractor's efforts, inspecting subsequent equipment, making adjustments, making them correct in its use and evaluating performance during initial use.

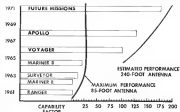
Experiment Data

The telemetered experiment data as recorded on magnetic tapes at ground acquisition stations on the satellite network require extensive processing and correlation before it is in a form suitable for use by the experimenters. This involves a sequence in the data processing branch. First step in the processing is a quick-look examination of the raw data to check its quality and suitability for subsequent processing, as well as checking its ground station equipment performance.

The raw data signals often are buried deep in noise and must be reconstructed into standard pulse form, a step called out by the experimenters. The data data is converted from its original multiple channel parallel format into a digital serial form compatible with the digital computer which will perform subsequent steps.

The serial format data tapes form as processed by a CDC-360 or an IBM 1401 to detect secondary loss of data or communications in the data.

Finally, after the digital format tapes have been cross-checked against the original telemetry tapes for accuracy, they are run through a computer which adds information on satellite position, altitude and attitude, if it is available, for each set of telemetered data. The data, now in final format, can either be printed out or read onto tape for the



INCREASED DATA: Spacecraft must send back ever greater amounts of data, including television pictures, with output greater than 500 bits per second. This requires a new 210-400-ft antenna.

Practical Dimensional Control of Large Missile Cases

Dimensional control in missile cases has in many instances been a perplexing problem requiring a solution beyond normal metal fabricating techniques. This is especially true in the larger missiles which are made up of two or more plates which, after bonding, are longitudinally welded together to form a cylinder and then two or more cylinders are joined welded together to form a complete missile stage. Although the problems of dimensional control are more easily recognized in missiles fabricated by the roll and weld technique, the same problems are found to be as acute when forgings are spun out to the desired wall thickness.

The most satisfactory approach to dimensional control has been through the incorporation of the Grimes mechanical expanding technique. Grimes has developed a metal forming machine tool which on a 16 foot long missile case is capable of tolerances within .005" of the geometric definition of a cylinder.

The dimensional capability, accuracy, technique and economy of this method, as well as the necessity for this method of missile case manufacture, has been proven by more than one major missile manufacturer utilizing 30 Grimes expanding missile machine tools to form and shape a half dozen of the current missile production.

In production, missile cases are originally fabricated or forged to approximate wall thickness but 1% undersized; these cases in standard or heat treated state, are then placed upon the expanding method of the Grimes metal forming machine and which in a matter of minutes expands the case to its final perfect size under controls sensitive to .005", ensuring setting for springback or other deformities or build-ups which may have been in the original piece.

It has been our experience that those firms with the most background in air-

side case manufacture are convinced that Grimes metal forming machine tools are by far the most satisfactory method of obtaining the required dimensional control for the welding or attaching of mating joints, ensuring tight, even, and flawless shape from rough cases, ensuring proper alignment and perfect fit for hand closure components, the hot forming and curing of case manufacturing of titanium, magnesium titanium, and other high strength alloys.

If your responsibility includes the manufacture of missile cases, we will be pleased to send to you our engineering data pack titled "Minimizing Dimensional Control of Large Missile Cases." Please address your request to J. Nelson, GRIMES MACHINE WORKS, INC., 554 North Walton Avenue, Chicago 40, Illinois. Wholly Owned Subsidiary of Inland Steel Co. and The Van Lue Group of Companies of Holland.

based computer to automatically program GAO operation, based on stated desires of the experimenter.

The Data Systems Division, one of five under the packing and data systems directorate, is endeavoring to devise the required GAO computer control program. The objective is to use a ground computer to simulate the GAO, with the mere button-actuated switch that exist for the spacecraft itself. For example, if one experimenter wants to view a particular portion of the launch during the next orbit, his computer will quickly determine whether the GAO can be maneuvered into this attitude in the required time, whether the desired data will be obtained by the ram, moon or one of the planets, and whether the spacecraft power supply can tolerate the experiment at this time, according to Dr. Joseph W. Slay, acting director of the division.

The division, which might better be called for computers facilities division, is responsible for operating part of the digital computers at Goddard, including the two IBM 7090s used in the Mercury computing center. The division also operates a third 7090, two IBM 1401s and an RCA 501, the last of said computers is input-output processor for the larger 7090s. The stable of computers also includes a CDC 160 and CDC 160A, used presently for editing Mercury tracking data. Present plans call for the purchase of another 7090 and 1401 for use with the prototype Nimbus meteorological satellite.

Within branches of this division are the men who program the 7090s for the required space flight mission, and operate the computers during a Mercury mission, working alongside engineers from IBM.

Another function of the division is to carry out orbital parameter determination such as ephemeris, progress and period. The satellites such as Titan, whose attitude can be controlled to a limited degree through the application of control to a coil around the satellite, this division computes the moment and torque for such attitude correction, based on an analysis of Titan attitude data. Calculation of the optimum launch window periods for different types of satellites is another responsibility. This division also does considerable scientific computation for other divisions and instruments at Goddard, Slay said.

Within the last several months, Goddard received 14 computer reservations to host its scientists on their latest machines and use technology in the near future. Goddard expects to host a group of computer manufacturers in its area requirements for a new satellite to be used for program control of the



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DAD. Sky and his driven often is proved to give orbital precision on a newly launched satellite, before it has obtained sufficient data from the existing Minuteman network. He points out that when the second network configuration was laid out, Vanguard satellites were expected to be launched only at a low inclination, south-eastern orbit, but today satellites are launched in a variety of other trajectories.

But with addition to the existing tracking network now programmed or requested the situation should become improved.



THREE 3 satellite is launched by Douglas Thor Delta from Cape Canaveral. Satellite and vehicle are managed by Comsat, which also collects, processes data.

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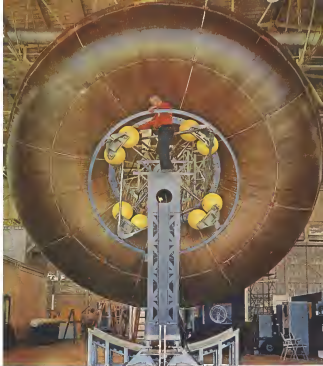
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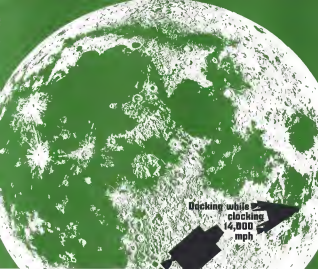
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NASA Strives for Procurement Flexibility

Washington—National Aeronautics and Space Administration, less than four years old and still a bureau completely by government procurement standards, is developing a financial system keyed to a philosophy that money is a dynamic tool for reaching national technical goals rather than a limiting element.

Dollars are considered in combination with the national technical capability and together these determine the total resources to be committed to space.

With this approach, the space program avoids the headache of an overriding desire to balance the books. In short, it is designed to be flexible enough to undertake a significant breakthrough or a new project that was not programmed, and strong enough to eliminate any project that has reached a dead end.

NASA is strong enough to take calculated risks in the way it does business, but some of its innovations are in technique and not in basic procedure. Competition that has arisen has stemmed mostly from the fact that its prime contractors are the same industrial firms that work closely for the Defense Department.

NASA Departments

By law, NASA's procurement procedures closely follow the Armed Services Procurement Regulations. But the agency is developing its own character, and industry is finding significant departures in the emphasis that NASA places on such items as quality assurance, on-time delivery and performance.

The impact of these departures will become pronounced in Fiscal 1963, when NASA expects more than 150,000 different procurement actions involving contracts valued at more than \$3 billion. NASA intends to enter formal contract clauses covering many of the quality and performance requirements that previously were only implied.

Although the agency can experiment with its procurement techniques, it can not do so on its flight program, where man rating and reliability of hardware must be absolute or no matter how complex the system. Unlike the usual development program, where some of Atlas or Titan vehicles could be launched before the system was considered operational, much of the winged-out program for the large Saturn C-5 and Nova space booster will have to be accomplished before first flight.

It is within this framework of non-commercial cost per item, a flow of cash that is to be produced and a need for the utmost in reliability that NASA sees the demand to improve greatly as detailed government procurement practices.

NASA has completely decentralized its procurement. Contracts are written at headquarters and at 30 field contrac-

tor proposals and specifications. Ordinarily, the project chief is headquarter because the chairman of the source evaluation board, which will include headquarters and field experts in both management and technology.

An evaluation board establishes criteria and develops a report for proposals, which is sent to a preferred list of companies that NASA considers qualified to perform the job. Bidding is not restricted to this list, but NASA has found that it very seldom receives bids worth serious consideration from companies that were not on the original list for a particular competition.

This is the beginning of a two-step competition designed to help reduce the need for what NASA calls "brokers-awake"—the preparation of elaborate and costly proposals in a large number of companies when only one or two will be awarded contracts.

Pre-Proposal Briefings

Pre-proposal briefings are held to acquaint potential bidders with the complexity and difficulty of the job to be tackled. In most cases, the majority of companies that attend pre-proposal briefings drop out of the running by the time the formal bidders' conference is held.

Bids for pre-proposal are distributed at the bidders' conference.

For competitions involving more than \$5 million, evaluation board reports are

NASA Contractor Statistics

National Aeronautics and Space Administration's largest contractor is North American Aviation, Inc., California, leads all other in dollar value of NASA contracts, and the Marshall Space Flight Center is the agency's biggest spender, according to the most recent fiscal summary issue by NASA.

This report, covering the six-month period which ended last Jan. 1, shows North American received payments totaling \$47.6 million, McDonnell Aircraft, \$37.4 million, Douglas Aircraft, \$12.7 million, United Aircraft, \$10.4 million, Ling-Temco-Vought, \$12.5 million, Grumman, \$10 million, Aerojet, \$9.5 million, Radio Corp. of America, \$7.3 million, and Chrysler and Boeing, \$1.7 million.

Contractors' share payments were paid through the Defense Department are not included. These payments are \$105 million for the period. If these contractors were included completely such as General Dynamics, which supplies Atlas missiles, and Lockheed, which supplies the Agency upper stage, would contract share from now high as the NASA list.

For the same period, Lockheed contracts received \$190 million, Minnor, \$10 million, Aerospace, \$17.6 million, Ford, \$17.1 million, New York, \$21 million, Texas, \$15 million and Maryland, \$12.2 million.

Marshall Space Flight Center had 15,000 procurement actions during the six-month period, obligating \$157.3 million. Western Operations Office had 540 actions involving \$214.2 million; Goddard Space Flight Center, 4,600 actions involving \$71.6 million; Marshall Spaceflight Center, 1,410 actions and \$45.2 million; Langley Research Center, 11,000 actions and \$12.9 million; headquarters, 3,100 actions and \$30.9 million; Lewis Research Center, 10,700 actions and \$12.9 million; Ames Research Center, 5,000 actions and \$6.7 million; Wallops Station, 1,400 actions and \$6.5 million and the Flight Research Center, 2,500 actions for \$1 million.

NASA Procurement Directory

Installation	Procurement Officials	Specialty Areas
NASA Headquarters Washington 25, D.C.	Albert A. Cloggett, procurement officer E. W. Gantrol, small business specialist	Foreign government and foreign commercial contracts studies and surveys in research and development and management.
Ames Research Center Moffett Field, Calif.	A. S. Hertzig, procurement officer Donald J. Davis, small business specialist	Re-entry physics, environments, aerobiology, biotechnology, environmental biology, guidance, stabilization and control.
Langley Research Center Langley Station, Hampton, Va.	Shirwood L. Butler, procurement officer Joseph R. Brog, small business specialist	Aerodynamics, heat transfer, materials, structures, fluid mechanics, guidance and control, development of prototype simulators and research instrumentation.
Goddard Space Flight Center Greenbelt, Md.	Gordon H. Tyler, procurement officer Henry J. G'Heek, small business specialist	Complete systems in space sciences and satellite applications and in tracking, data acquisition and data reduction. Theoretical program in astrophysics, celestial mechanics, plasma, lunar surface, earth and planetary atmospheres.
Jet Propulsion Laboratory Pasadena, Calif.	T. W. Condes, procurement officer G. R. Lawrence, small business specialist	Propulsion, aerodynamics, chemistry, guidance, communications, physics and mechanics relating to complete unmanned lunar and interplanetary spacecraft.
Western Operations Office Santa Monica, Calif.	Boris Sample, procurement officer Alex Wilmore, small business specialist	West Coast contract monitor for industry, research organizations, NASA installations.
Flight Research Center Edwards, Calif.	Morris L. Bowling, procurement officer Lloyd J. Welch, small business specialist	Aircraft aerodynamics, heating, spinning problems, simulation and flight support.
Wallops Station Wallops Island, Va.	Louis T. Birch, procurement officer Robert R. Bradford, small business specialist	Rocket-propelled vehicle experiments, including satellite payload prototype instruments. Sea-launched satellites and probes.
Marshall Space Flight Center Huntsville, Ala.	Wilbur S. Davis, procurement officer James S. Wilmore, small business advisor	Development and prototype construction of Saturn-class launch vehicles, including aeroballistics and related sciences, simulations and data reduction, research in manufacturing, guidance and control systems, vehicle checkout and launch.
Lewis Research Center Cleveland, Ohio	John Biggs, procurement officer Norman C. Prusky, small business specialist	Chemical and nuclear rockets, electric propulsion systems, power generation and space environmental systems.
Leitch Operations Center Cape Canaveral, Fla.	Gerard A. Michoud, procurement officer Carl J. DeM, small business specialist	Construction, supplies, materials and services for vehicle preparation and launch.
Manned Spacecraft Center Houston, Tex.	Bowen W. Long, Jr., procurement officer K. T. Christman, small business specialist	Marscury, Gemini and Apollo manned spacecraft, with some advanced technical development studies under contract.
Space Nuclear Propulsion Office Germantown, Md.	George Kimball, procurement officer	Project Rover and the Nemo nuclear engine, advanced technology, test facilities, reactor and vehicle development.

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downward to NASA Associate Administrator Robert C. Scarsone, Jr. He and Deputy Administrator Hugh E. Dryden then review the report and make a recommendation to NASA Administrator James E. Webb, who makes the final decision.

Top NASA officials insist that there has been no case where a contractor was selected solely for political reasons. They concede that the political facts of life have been taken into account, but they say that so far they have never been placed in the position of awarding a contract to a company that did not have full technical capability to handle the job. Technical considerations are given top priority, then management considerations, and finally NASA's desire to bring new companies into space work to broaden the base of technological competence is weighed.

Increasingly, NASA is trying to cut down cost and manpower and improve the selection process is highly complex competition such as Apollo and Mars by awarding several conceptual design study contracts before it picks a hardware developer. This is the first phase of the two-phase competition. It is probably—but by no means guaranteed—that one of the study companies will be selected to develop the hardware for the space agency.

NASA relies primarily on two types of contracts.

• Cost type, either straight reimbursement or with a fixed fee. During the six months ending last January, 42% of NASA's contracts were cost-plus-fixed-fee, which is considered the most attractive type when technical uncertainties are involved. By law, fees are negotiated in dollars, and they average 6 to 7% of the total job cost.

• Fixed price, which account for 17% for NASA's contracts. The type used when the scope of services to be provided can be clearly defined. It is the type usually used for conceptual studies in which negotiations are in terms of man-hours.

Insisting new twists into classical government procurement practices has been difficult at a time when NASA's budgetary expansion has paralleled the country's growth in responsibility. NASA began its life as an agency a quarter of the way through Fiscal 1959 with an appropriation of \$300 million. By budget for Fiscal 1963, which began July 1, authority to \$3.6 billion—about 75% of which is earmarked for research and development.

Most of the major contracts in the future will contain new clauses concerning:

• Quality assurance—with provisions for inspection, prime supplier contractors and suppliers. The quality assurance provisions were developed beginning more than a decade ago by the former

Army Ballistic Missile Agency research and development team, most of whom transferred to NASA to form the nucleus of the Marshall Space Flight Center.

• Program Evaluation and Review Technique (PERT)—A computer analysis method for reporting critical program events, modeled after Navy's Polaris PERT system.

• Financial Accounting—Budget Review recently approved a NASA program which requires that contractors report monthly their total costs to date and a projected total project cost. This will be the first use of such a technique in government procurement history.

NASA is aware that the innovations will add to the complexity and costs of projects. It has already heard complaints of over-management and government red tape. But the agency feels the expense of space projects and the requirement for reliability, particularly in manned space flight, makes fiscal contract provisions in these areas logical and necessary.

Emphasis on quality assurance is designed to eliminate flight failures by microscopic inspection during production and checkout. PERT will focus management attention on starting problems and on activities that are likely to become critical. Financial reporting will help to verify one of the most overhauling research problems—cost estimating.

"One NASA official put it bluntly: "We're not satisfied with our own cost estimates. We are devoted to assisting our contractors' estimates."

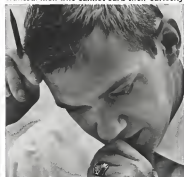
Incentive Contracting

Along with tighter management controls, NASA is usually attempting to find ways of adding incentives to contracts. Wesley Hoseney, director of administration for the Marshall Space Center, and it is difficult to find a "handle" on which to base awards and development incentives when an item has never been made before. The target, he said, must be objectively measured, but it cannot be subject to judgment after the job has been finished.

Berthel L. Bowers, a headquarters procurement officer, pointed out that the incentives problem is complicated by the small number of items NASA makes under one contract—for example, the Apollo spacecraft. Even though this contract will be sizable in dollars, members of spacecraft is to be produced will be relatively low.

NASA is willing to pay premium fees if performance is good, and performance may be the optimum basis for research and development incentives. Ernest W. Bailett, procurement director, said the agency is considering a system of contractor performance evaluation which will take into account the general qual-

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Quality Assurance

The quality assurance program consists of three parts:

- Inspection agency provisions, which spell out inspection plans and methods of monitoring and reporting on the contractor quality assurance system. Essentially, it is the guide to be used by Defense Department representatives who monitor NASA contracts, and by NASA plant representatives.
- Major contractor provisions, describing requirements for relation of quality to reliability, the quality program plan, design control, qualification tests, control over subcontract quality, fabrication and process controls, documentation, corrective action and quality auditing.
- Supplier provisions, which call for documentation of the company's inspection plan and defect-prevention methods for components it buys from others.

Within 45 days after the award of a contract, the prime contractor must provide a plan which shows how his quality program will operate and what changes are necessary in his program to meet NASA contract requirements. He is then required to maintain and document control over design and development, including review of drawings and specifications and qualifications tests, materials which he processes and inspections and standards for tests and reviews, government furnished materials inspection, articles which he fabricates, calibration and maintenance of his test equipment, and packaging, handling, storage and shipping.

NASA's major contractor quality assurance provisions also require a training program for employees involved in quality control inspection and those who purchase and fabricate parts.

The provision call for a monthly status report along with accurate reports on any failures or difficulties. NASA will retain the prerogative to review the qualification status list, end-of-test plans, and end-of-test and inspection procedures.

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view, establishes his general quality program plan, test and inspection provisions, process control procedures, storage procedures for end-items and special sampling plans.

Provisions for suppliers, many of which are small businesses, are considerably less stringent than those for prime system contractors. Supplier inspection system classes generally spell out responsibility for control of procured source material quality, inspection and test of their own components, and process control.

NASA PERT System

NASA's PERT system is similar to the basic Navy PERT system in that it uses data processing equipment, it establishes a network of activities in a dependent sequence flow array, and it determines critical path and slack determination. NASA PERT uses a single time estimate for network activity, while the Navy system has a three-time estimate. Another variation is that NASA PERT uses the milestone, or top level event, as the network schedule.

The system was established in-house last September as a management tool for project and systems managers in the field, and two months ago it was extended to contractors that are adaptable to PERT.

Contractors and NASA centers work as a team in accomplishing PERT, with NASA defining the needed and scope of contractor networks and the contractor developing these networks, also tying events and activities constituting the networks, and estimating direct labor involved with each activity.

Project charts receive the following PERT information is weekly from the NASA-contractor team:

- Summary outlook—no comment for activity performance data on the master schedule, any changes in network from the previous report and reasons for the change.
- Significant progress—describing milestones reached.
- Project risks—identification and discussion of critical paths derived from the latest computer output.
- Cumulative action taken, and its effect on resources.

One of the best ways NASA has found to spread the base of spare procurement has been to enlarge the opportunities for small businesses—firm employing 500 or less. In addition to some "set-aside" actions, in which only small businesses can bid, the agency recently began a policy of carrying names and addresses of prime contractors needed to bid on projects in the Component Department inventory. The policy is for amounts of \$100,000 and over.

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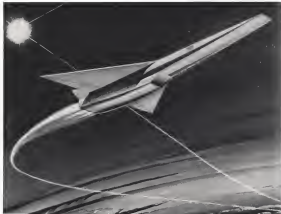
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Contract Research Reflects NASA Growth

Washington—One of the most significant indicators of the National Aeronautics and Space Administration's growth is the amount of research the agency lays and supports to complement research being done in its own centers.

When NASA was established almost four years ago, it had a budget of about \$1 billion to support research conducted under grants and contracts. In Fiscal 1963 it will spend \$100 million, directly and indirectly, for sponsored research.

The agency's research interests run across the major scientific spectrum. An estimated 500 grants and contracts were funded in Fiscal 1962. This is more than one-third of the proposals submitted during the year, and the space agency obligated about \$18 million to support them.

Research Philosophy

Philosophy behind NASA's research support is to let people with ideas come to NASA, according to Dr. Thomas L. K. Smith, director of the Office of Research Grants and Contracts. In fact, the scope of new ideas does not become restricted and the publicity recognizes that the space agency will sponsor most research projects that have merit.

Objective of the program is to tap the best minds in the country, in universities, industry, nonprofit organizations and government laboratories. An obvious intent is the stimulation of training and interest in aviation, which will furnish scientists and engineers to both industry and NASA in the future.

Dr. Homer E. Newell, director of space contracts, recently pointed out the critical role that universities play in the space program. "The government laboratory, university, the nonprofit foundation, all are up trained trainees without depriving of their vital resources," he said. "The university alone replenishes the resources by the production of new capabilities and scientists."

NASA will attempt not to set up activities that tend to draw strength away from the university or show the researcher away from his teaching, Dr. Newell said.

Firm Contract

First contract for a researcher with a proposal is Dr. Smith's office. The proposer does not have to follow a standard format. What NASA wants to know essentially is the problem, how it will be attacked, what will be accomplished, and the effort that must be expended.

If the proposal comes from a university or non-profit organization, it becomes a candidate for a grant. If the proposer is a company, the proposal will be funded by a contract.

Research grants can be made active for as long as three years, and NASA encourages proposals for long-term projects.

Research contracts normally are awarded on a cost-plus-fixed-fee basis because costs cannot be accurately forecast.

Once a proposal is received from any source, it is diffused throughout the NASA organization wherever the space is involved. If it is an idea for an experiment to be carried on a shuttle, the proposal is disseminated and presented to the Space Science Steering Committee for consideration. This committee selects all NASA satellite and probe experiments.

If the proposal is in a field in which NASA is expert, the proposal review may be conducted completely in-house. It seems where the agency has limited competence, Dr. Smith's office conducts a panel of consultants, which recommends action.

Program Financing

Small directly administered programs, but funding can come from a variety of offices. In the lunar and planetary program, for example, the Office of Space Sciences will fund sponsored research projects from which it will benefit. However, participation in the program is flexible, and it is indicative of early widespread national interest.

Of the total program project participation, 35% is furnished by universities. The percentage goes as high as 50% in Mars and 60% in Mercury.

Research that is unusual or preponderant will receive far about \$10 million in Fiscal 1963, and NASA has

about 510 million available for grant-making, fundamental research.

Research activity should not be confused with hardware development, however. Once a research project reaches the flight hardware stage, it transfers its administration from the Office of Research Grants and Contracts to the headquarters program office most directly concerned.

Fundamental Studies

The Lunar Corp of New Haven, for example, has been conducting fundamental studies for the past few years on closed chemical systems for the reduction of carbon dioxide into oxygen and carbon. NASA has funded these studies in the amount of \$498,000. Although the research may require production of some hardware, this is in the category of laboratory instrumentation and not flight hardware. If interest is successful, funding will shift to the Office of Manned Space Flight when NASA decides to buy the system for a spacecraft.

Smith's office awarded the Massachusetts Institute of Technology a \$480,000 grant in 1960 to develop a laboratory prototype of the Apollo guidance and control system. Manned Spacecraft Center approved MIT's design last May, and at that time, the funding shifted from headquarters to the center.

In the most recent tabulation of active grants and contracts, NASA was doing business with 67 colleges and universities, 27 companies, 31 non-NASA government laboratories, and 11 non-profit organizations. About 80% of the dollar is awarded in grants to universities and non-profit organizations. The remainder goes to industry and government laboratories in contracts.

Although there are many small schools and companies represented in the active list, NASA favors any pattern of geographical distribution is seen. If the agency is to be interested in quality research rather than an attempt to sponsor as much research as possible, knowledge of the scope of NASA's in-

Role of Universities in Space Research

"Academizing the space mission requires the strong and vigorous participation of our universities and colleges," according to Dr. Homer E. Newell, director of National Aeronautics and Space Administration's Office of Space Research. "NASA's responsibility in this relationship is to be 'in the line' of the support, so that universities and colleges can participate in the space program, Dr. Newell said.

Although NASA cannot meet all demands, the agency "wants really to be in an appreciable fraction of its resources" in the university space program, and to a limited extent in provision of buildings and facilities, he said.

Universities "must have their own credit capability for the space program and allocate to appropriate fractions of their material, as well as human, resources to the effort," he said.



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search interest is this general summary of items open to support:

• **Fundamental research**—Basic and applied research related to astronomical and space sciences. It includes physical sciences, either theoretical or experimental, in areas such as astrophysics, chemical and energy transformations, extraterrestrial plasmas and phenomena, and mathematics as it applies to control theory, trajectories and administration theory.

Engineering Sciences

In the engineering sciences, NASA is interested very broadly in development of new techniques and exploitation of scientific knowledge. Critical problem areas include energy propulsion and conversion; electronic process in instrumentation, guidance, control and communications; mechanism of orbits, trajectories, guidance and structures; hypersonic fluid dynamics; and system analysis and control.

Areas of research open in cosmological sciences include astronomy, astrophysics, geophysics, geophysics, natural particles and cosmic rays. Socio-economic studies emphasize assessment of the effects of space technology on man.

• **Space flight research**, covering presently the sciences involved in launch vehicle and specially developed. Critical areas include most aspects of accurate space investigations using sounding balloons, satellites and lunar and planetary spacecraft.

NASA also is interested in determining specific future application potentials, such as those under way in space navigation and astronomical satellite programs.

Other Areas

Other broad areas of interest in space flight are operational problems of manned space flight, research in trajectory determination, data acquisition and processing, fundamental studies of advanced vehicle systems and booster recovery techniques and fundamental studies of chemical rocket propulsion, analysis and space power technology.

Life sciences research associated with man in space and the search for extraterrestrial life. Categories of interest are flight medicine and biology, searching biotechnology and the specialized aspects of biomedical experiments, space medicine and behavioral sciences, which concerns physiology, metabolism, nutrition, psychology and sociology as it applies to manned space flight, space biology, involving research in life on planets and in space, and the effects of space on biological phenomena.

Small experiments that outgrowing the space shuttle because they appear too restrictive. Unselected proposals are evaluated as to how they relate to NASA's objectives—its long-range objectives, its immediate goals of the scientific and engineering disciplines, that technology is interpreted very broadly.

NASA Program

That fall, NASA will begin a general program of stimulating the flow of new research in most industrial and government needs of the expanded space program. The program, also to be administered by SCRI, involves equating 100 post-doctoral students at 10 universities. Students will receive stipends and allowances totaling \$7,400

annually, as well as tuition and fees. Universities are selecting candidates for the program on the basis of their academic records and ability to complete the necessary work for doctorates in their field.

Because the research which NASA supports should have some relevance to the total space program—even though it can be remote—one of the major requirements for those interested in the program is having the objectives. For this reason, NASA encourages publication of reports of its sponsored research in a form structured to that need for its own in-house technical notes, technical memoranda and research reports.



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Flight Photo Shows Bristol T.188 Test Details

First test trace photo of Bristol T.188 shows steel mesh details (AW Apr. 16, p. 31), made during pilot landing tests at Edwards Dryden flight research facility, shows square aperture on bottom of fuselage which a vent for dumping air from air conditioning system. Pylon on port side, apparently would support air intake extension and goal of test holds military parachute around parachute is evident in tail cone of the standard steel mesh detail.

Nuclear Missiles Sought for Submarines

Navy has requested the Atomic Energy Commission to develop a configuration of the Project Pluto nuclear rocket engine compatible with a missile for launch from Polaris submarines.

The nuclear-powered missile would have the advantage over Atlas, Titan, Navstar, and Polaris of inherent range, conventional state capability, and substantially greater payload. USARF is actively studying these missile configurations for the Pluto regime.

AEC witnesses, regarding the proposal for a submarine version in testimony before the House Appropriations Committee released last week, also said that beyond the immediate goal of an offensive weapon, an adaptation of the nuclear rocket engine for a reconnaissance vehicle is also being considered.

Funds Increased

As Force plans to increase its funds for Pluto from \$7 million in Fiscal 1962 to \$24 million for Fiscal 1963, AEC, which has already invested about \$100 million in Pluto research and development since 1956, has earmarked \$25 million for Fiscal 1963.

AEC estimated that a total of \$640

million will be required over the following three years, 1961-66, to bring Pluto through flight test \$900 million by Air Force and \$140 million by AEC.

Dr. Glenn T. Seaborg, AEC chairman, told the committee that as a result of highly successful tests last fall of Terry 2A-6—the first engineering test

device in the Pluto program—AEC dropped Terry 2A-2 and proceeded directly to Terry 2C, designed to bridge the gap between the engineering test device and a feasible powerplant. Terry 2C testing is scheduled to begin in 1963.

The design, growth, operating temperature and use of the Terry 2C nuclear apparatus the requirements for a propulsion system needed for flight at sea level, Seaborg said.

Management Planning

AEC and Air Force are now considering the type of management which should be established for the follow-on program to Terry 2C, including development of nuclear test and flight test. Seaborg reported "The need and interrelated duration of the follow-on program, including the development of an engine and reactor and propulsion systems, will require close coordination among the participants," he said.

On other weapons projects, Seaborg reported:

• Project Rover for nuclear rocket propulsion: AEC will start design and fabrication of reactor in Fiscal 1963

for Project Phoenix—AEC's advanced effort to develop high power levels required for space-based space station. The Navy nuclear propulsion system, the first phase of Project Rover, preceding Phoenix, is scheduled for flight demonstration in 1966-67. AEC contracted last July with Aerojet-General Corp. and Westinghouse to develop the Navy engine. Seaborg said AEC hopes to determine the reactor design for development into the Navy engine during Fiscal 1963.

• Space space nuclear auxiliary power program: AEC will start procurement of long lead time items in Fiscal 1963 for the advanced Stage 50 program for development of large reactor-driven space plants as the equivalent cargo to serve as sources of power for communications, television, and radio stations. Seaborg noted that Stage 50 will require advanced technology in materials and reactor controls.

Technical Problem

To explore the severe technical problem involved, he said, a lithium cooled reactor experiment is planned for 1965. AEC has earmarked \$5 million for facilities at Idaho National Research Testing Station for testing the experiment, and \$1.4 million for modification of facilities at Pratt & Whitney Aircraft Division in Middletown, Conn., for fabrication of large aluminum components to be utilized in the experiment.

Advanced OSO

As many as three parallel study contracts for an advanced Orbiting Solar Observatory (OSO) are expected to be awarded shortly by National Aeronautics and Space Administration's Goddard Space Flight Center. The company which performs the bulk of the three studies will then get continued funding through flight hardware without going through competitive bids.

OSO parameters are being made now by Goddard by 15 studies including: Air Force Instruments Laboratory, Red Bank, Pa.; General Electric, Cincinnati; Radio Corp. of America, Republic Aviation, Space General, Space Technology Laboratories and Westinghouse.

Advanced OSO will be a more sophisticated satellite than the NASA Ball Balloon OSO which performed well recently, possessing extremely high pointing accuracy (AW May 23, p. 21).

West German F-104 Operations Resume

West German air force resumed F-104 flight operations early last week after grounding the aircraft for one day following the high-altitude accident on Oct. 15 (AW June 23, p. 31) that touched off a new political storm.

The accident which resulted in the grounding order, wiped out approximately half of the Luftwaffe's effective F-104 maintenance corps and prompted charges and debates within parliament and the West German press over the 16-month-old decision to purchase the advanced aircraft. A special report was Defense Minister Franz Josef Strauss.

Air Force and Defense Ministry also were engaged for permitting the formation of an aerobically team using the high-performance F-104, and some members of the opposition Socialist Party last week were demanding a full-scale parliamentary investigation of the incident.

At the time of the accident, the fleet actually was preparing on the eve of a planned emergency deployment to still reach the status of the program—the formal declaration of the air force's first F-104 fighter wing at the time and date specified in original plan.

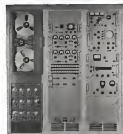
After the accident, which apparently occurred when two of the aircraft brushed wings as they came into a turn and then crashed, the other two, the emergency was closed to the public, and the aircraft subsequently were grounded to avoid any risk of a further accident until the problem had been solved.

Three of the pilots killed were German air force instructors, at Nuremberg Air Base near Bonn the fourth was a U.S. Air Force captain.



First Production HRB-1 Begins Tie-Down Tests

Marine Corps has accepted the first production model of the Boeing Vertol HRB-1 Sea Knight medium transport helicopter. Following tie-down of the first model on an amphibious lander headed by Col. Marine S. Cox, deputy chief of staff, the ship was placed in a tie-down rig for testing. Personnel for the helicopter, the test base aircraft at the first Verrill HRT-3, are two General Electric T58-GE-3.



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• NEWS OF THE WEEK

CAB Examiner Asks End to Schedule Study

Civil Aeronautics Board Examiner Edward Stodola has recommended that the Board end its investigation of a regulation requiring foreign flag carriers to file schedules with the U.S. for CAB approval.

In his initial decision on the investigation, which began early in 1966 (AW Jan 24, 1966, p. 41), Stodola found that the frequency and capacity were raised by the proposed regulation are "primarily a legislative and political problem which should be reviewed and passed upon" by both the Congress and the President.

Examiner Stodola said, however, that limitations on capacity and frequency can be imposed upon foreign flag carriers under section 403 (f) of the Federal Aviation Act of 1958.

In this respect, he said, should the Board, after consulting the State Department, decide not to sign or to wait for action by Congress on frequency and capacity problems, the Board should authorize individual proceedings under section 403 (f) of the act against foreign air carriers which the U.S. suspects of providing excess capacity.

Stodola expressed doubts that the difficulties the U.S. is encountering with foreign flag carriers justify a "regulatory control over capacity. Any action of the regulatory agency in the proposed regulation." He added that, even were the need for such a regulation manifest, the Board is not "the proper forum for the disposition of the serious issues raised by this proposed act."

The proposed regulation called for an amendment of foreign air carrier permits to require them to furnish traffic data and schedules to the Board for approval.

Such information would provide the Board with information on which to base the restriction of seat capacity offered by a foreign airline.

Tax on Airline Fares To Drop 5% on Nov. 16

Congress last week passed a transportation bill reducing the tax on airline fares from 3.8% to 5% effective Nov. 16. The Senate originally made the reduction effective Oct. 1 while the House passed a similar bill on Jan. 1 effective date.

Both the Senate and House rejected the Kennedy Administration's proposal to comply any airline tax reduction with new limits on ticket back and airfares.

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Settlement of FEIA, Airline Dispute Solved

Attempts to settle the yet more complicated case were slowed last week at Flight Engineer International Assn. members weighed a settlement proposal at Texas World Airlines (AW June 25, p. 45), and Pan American World Airways was reluctant to July 6 of a full, not court-order American with FEIA strike threat. Eastern Airlines was shut down by an enroute strike June 21.

Judge George Rosling delayed making a final ruling on the temporary restraining order issued June 10 after the National Mediation Board offered its services.

Eastern Air Lines, which did not seek another court order, was forced to lay off 18,000 employees. Eastern spokesman said that while the airline may seek an injunction to halt the FEIA strike, which was triggered by membership rejection of a settlement proposal made by Labor Secretary Arthur J. Goldberg and approved by FEIA headquarters officers.

FEIA and it was considering an appeal to Judge Rosling's order. Since the NMB has already failed in attempt to mediate the dispute at Pan American, FEIA contends that all provisions of the Railway Labor Act have been complied with and that NMB has no further jurisdiction in the dispute.

Settlement of the court compliance issue under the Goldberg proposal brought immediate protest from such as the union members at Texas World Airlines because it is D. Detroit, the TWU's executive president, agreed to drop FEIA demands for initiation of a new-union's license requirement to the union's contract. FEIA members on both Pan American and Eastern issue directly voiced the same objections to the proposed settlement and called for protest strikes.

Six Airlines to Ask Coach Fare Increase

Six airlines late last week had indicated they intend to ask the Civil Aeronautics Board for what would amount to a 7% increase in present coach fares as a means of reducing the diversion of passenger traffic from airlines to coach.

The proposed tariff, which will ask a 6% increase to replace the temporary six-month 3% rate granted Feb. 1, would bring coach fares to about 65% of first-class rates. At present, coach fare average about 70% of first-class rates, which the CAB feels is the proper relationship for the development of new traffic.

Each of the six airlines asking the

JPL Reorganization

Los Angeles-NASA's Jet Propulsion Laboratory has announced its Space Sciences and Physical Sciences Division into a single group to strengthen its space sciences activity without compromising fundamental physical sciences research, according to William H. "Dick" Williams, director of JPL, June 1, 1967.

The combined technical division, absorbing the eight civilian staff previously located within the two divisions, will be the second largest at JPL, with over 300 professional and supporting personnel and a budget expected to be in excess of \$30 million annually.

Previously, Physical Sciences directed staff to basic physical sciences work, including spectroscopy and astrophysics, while Space Sciences activities were engaged in flight operations. The combination of the two is intended to strengthen work, eliminate much of the overlap in technical and technical.

Robert V. McLaughlin, former chief of the Physical Sciences Division, will hold that position in the combined division which will retain the same Space Sciences Division. Marshall Evans, previously acting chief of Space Sciences, will be deputy chief, following says.

(see p. 168) to take up slack between end of recent Ranger series next year and start of the Surveyor program.

Parallel six-month study contracts for advanced analysis of rocket systems for advanced multistage transportation vehicles (AW Apr. 3, p. 50) to establish and supply permanent lunar base have been awarded by NASA's Marshall Space Flight Center to Lockheed Martin and Spacor Co. (\$144,790) and Lang-Tonno-Voght (\$149,387).

Last of T44 B-52s built by Boeing rolled out at Wichita (Boeing's final assembly line June 22nd). The B-52H will enter flight test in July and be delivered to Strategic Air Command in September. Of the total Stratofortress production, 456 have been built at Wichita. At peak B-52 production at Wichita, employment reached about 55,000. It is now approximately 21,500 and is expected to be about 2,000 by year end. Nearly 4,000 subcontractors in 43 states were involved in the B-52 effort.

Se Leslie Rowan, managing director of Valiant, Ltd., has been appointed project chairman of British Aircraft Corp. A British-British industry center.

New Inroquois Purchase

Three appropriations committees last week approved passage of the additional \$600 million for the purchase of 1962 F-4s to be received by inventory of Fiscal 1962 funds from other Army accounts.

Army's original Fiscal 1962 budget authorized \$67.5 million for purchase of 252 Inroquois, and its Fiscal 1963 program authorized \$194.4 million for Inroquois procurement.

Sen. J. Bennett Johnston, D-La., last week said that the probe include possible revision of existing economic and operating regulations, airport construction problems, cost of various air craft types, estimated traffic response, and defense, postal and security needs.

Political sponsor over the BOAC-Cairmont joint venture (AW June 11, p. 45) began last week in London with Minister of Aviation Peter Thorneycroft drawing details of monopoly and defending the association of a public company with a private one. Opposition in Parliament charged Thorneycroft with "monopoly" to place sole product within under a monopoly at the expense of the Air Transport Licensing Act of 1961, designed to give independent a larger share of the market.

James L. Kerley will become vice president finance and treasurer of Trans-

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increase—Braniff, Continental, Delta, Eastern, National and Northwest—claimed that revenues were declining as more passengers switched from jetliners to take advantage of the low coach fares. For example, Eastern said that its percentage of coach traffic rose from 53.1% in the first four months of 1961 to 57.4% in the same period of 1962, excluding Air Shuttle and Air Bus traffic.

News Digest

Boeing-OSAF Dyna-Sonic mounted space glider last week was re-designated the X-20. The change is intended to emphasize the experimental nature of the project.

Navy Col. Walter M. Schmitt, Jr., has been selected to pilot the Messerschmitt Bf 109 fighter that manner which will be planned for an exercise in an exhibit, National Association and Space Administration and last week (AW June 4, p. 16), USAF Col. Gordon Cooper, Jr., will be backup pilot.

NASA headquarters is expected to authorize the addition of five Ranger spacecraft (RA-10 through RA-15) to its manned lunar exploration program.

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For today . . . and the tomorrow ahead, Sikorsky requires widely varied talents to build and further develop VTOL systems to the degree of sophistication demanded by advancing technology. Our needs continue for men with experience in such areas as: *aerodynamics* • *human factors engineering* • *automatic controls* • *stress engineering* • *weight prediction* • *systems analysis* • *computer programming* • *mechanical design* • *autonavagation systems* . . . among others.

If you are the engineer who thrives on demanding assignments—if you work best in an environment of constant and stimulating challenges—we would like to evaluate your role in Sikorsky's future. Please send your resume, including minimum salary requirements, to Mr. Leo J. Sikorsky, Personnel Department.



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A factual statement on career opportunities for scientists and engineers
from James E. Webb, head of NASA



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James E. Webb

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